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VOL XVIII

Engineering  
MAY 10 1926  
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# JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS



MAY 1926

Summer Meeting Program

SOCIETY OF AUTOMOTIVE ENGINEERS INC.  
29 WEST 39TH STREET NEW YORK

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# Are You in the Price War? Watson Isn't

**W**HENEVER there is competition in results, there is war in price. To *keep* out of a price war, or to get out of one, you must keep yourself, or lift yourself, out of results competition.


A car with a comparatively small motor can out-travel a car with a large motor provided the first car possesses better roadability. The larger motor has the superior power, but without equal roadability its power cannot be used.

Roadability, therefore, becomes the limiting factor in car ability.

Wheelbase alone will not give you roadability. We know of cars with a small motor and short wheelbase which can way out-travel cars with a tremendously powerful motor and long wheelbase.

Improvement in roadability is an immediate lift out of results competition. With superior roadability, your dealers can immediately demonstrate superior car ability. The change can be quickly made, the cost is but a very few dollars, and the value is greater than any amount of additional, but useless horsepower.

Roadability is your quick, cheap and only way out of results competition and price war. But it must be *true* roadability—not a mere gesture at roadability. We can do the job for you—quickly.



**John Warren Watson Company**

Original and Sole Manufacturers of Stabilation

Twenty-fourth and Locust Streets

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# WATSON STABILATORS

**BUILT TO DO ONE JOB RIGHT**

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# THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XVIII

May, 1926

No. 5



## Chronicle and Comment

### Summer Meeting Account in June Issue

In an attempt to bring promptly before our members a detailed and authoritative account of happenings at French Lick Springs, extensive arrangements have been made to expedite the publication of technical papers and the illustrated story of all Summer Meeting activities. These features will be published in June issue of THE JOURNAL that will be mailed to the entire membership as soon after the closing of the Semi-Annual Meeting as conditions will allow.

### Standards Committee Division Reports

AT the Standards Committee Meeting on June 1, recommendations to the number of 37 will be submitted by 14 Divisions of the Standards Committee. This is the largest number of recommendations that have been submitted for Standards Committee action since 1920. These reports are given in full in this issue of THE JOURNAL, beginning on p. 411, to provide those interested with an opportunity to review the reports prior to the Standards Committee Meeting. Comments mailed to the Society office by members who are not planning to attend the Summer Meeting will be submitted at the Standards Committee Meeting as written discussion.

### The Annual Nominating Committee

TWELVE of the Sections have taken care of the matter of electing a representative on the Society's Nominating Committee, which will function at French Lick Springs, Ind., during the Semi-Annual Meeting, and an alternate to serve if for any reason the representative finds himself unable to attend the Semi-Annual Meeting. The Section that has not yet chosen a representative and an alternate will do so at the regular meeting of that Section in May.

The Society's Constitution provides that the Annual Nominating Committee of the Society shall consist of one Member of the Society to be chosen from and by each Section of the Society prior to the Semi-Annual Meeting; and three Members of the Society who shall be elected at the business session of the Semi-Annual Meeting preceding the Annual Meeting at which officers are to be elected. Of the three members-at-large, no two may reside in the same Section territory. The business

session will be held at French Lick Springs, Ind., on the evening of Tuesday, June 1.

### Meeting Dates Definitely Settled

ON Sept. 2 and 3, the Society's Aeronautic Meeting will convene at the Bellevue-Stratford Hotel in Philadelphia. On the following day, the National Air Races, under the sponsorship of the National Aeronautic Association, will open. The Sesqui-Centennial celebration will offer an added attraction to members who find it possible to visit Philadelphia to attend the Aeronautic Meeting.

It has been decided that the Automotive Transportation and Service Meeting will be held at the Copley-Plaza Hotel in Boston, on Nov. 16, 17 and 18. Chairman J. F. Winchester and his committee already have the arrangements well in hand.

### Summer Meeting Projects

A DETAILED summary of the events that will make the Summer Meeting this year most attractive will be found commencing on p. 441 of this issue of THE JOURNAL. A number of very interesting technical sessions that have been provided by the Meetings Committee will assure an adequate interchange of ideas and the dissemination of engineering information of great value to our members. Technical features combined with an ample schedule of entertainment and recreation activities promise to establish a new record for this important event in the Society's calendar.

At this time a sufficient number of reservations have been made to indicate the probability of an unusually large attendance.

### Inclusion of Papers in Transactions

SURPRISE is frequently expressed by members upon receipt of a volume of the TRANSACTIONS that all the papers printed in THE JOURNAL for the respective 6-month period do not appear therein. The Publication Committee receives semi-annually a list of the papers that appeared in THE JOURNAL during the last preceding half-year period. This list is considered by the members of the Committee and the inclusion or exclusion of each paper is determined on the basis of whether or not it possesses permanent value. Some material of great cur-

rent interest is therefore omitted. On this basis, approximately 56 per cent of the papers published in THE JOURNAL in a half-year have been included in the last three parts of TRANSACTIONS considered by the Committee.

#### International Standards Association Being Formed

**A**N important step in world-wide standardization activities was taken during the third international conference of the national standardizing bodies of 18 countries in New York City during April at which a proposed constitution was drafted for an International Standards Association. This Association is to be constituted of the national standardizing bodies in all countries accepting the constitution and will influence to a greater or less degree the work of the American Engineering Standards Committee and the Society, especially in those projects for which the Society is a sponsor or which affect the automotive industries. Informal international conferences were also held during the convention on screw threads, limits for fits, bolts and nuts, preferred numbers, and ball bearings, a further account of which appears on p. 437 of this issue of THE JOURNAL.

#### Operation and Maintenance Vice-President Proposed

**R**EPRESENTATION on the Council of the Society of a rapidly growing group of members is provided by the amendment proposed by J. F. Winchester at the Annual Meeting in Detroit last January. If adopted, this amendment will abolish the office of Second Vice-President representing stationary internal-combustion engineering and substitute therefor a Second Vice-President representing operation and maintenance.

The proposed amendment, which has been sent to the voting members of the Society and will be discussed at the Semi-Annual Meeting at French Lick Springs next month, is printed on p. 474 of this issue. A number of letters have been received commenting on the proposed amendment and pertinent extracts from these will also be found following the text of the amendment. Members are urged to study the amendment and these comments so that a full discussion of the subject can be had.

#### Frosting on the Cake

**S**EVERAL months ago the Detroit Section held a meeting that proved to be among the most interesting and far-reaching in its effect of any event in the Section's history; it included a trip to the General Motors Proving Ground at Milford, Mich., where the Corporation allowed the visitors to inspect the grounds and equipment and very generously provided a delectable dinner that was followed by an engineering paper by O. T. Kreusser, engineer in charge. Some 500 members of the Sections in Detroit and other cities derived considerable pleasure and benefit from the undertaking and became more enthusiastic than ever in their appreciation of the value of Society and Section membership.

This experience is illustrative of that reported by other Sections that have provided similar events, and there can be no doubt as to the advisability of injecting into the meetings program a reasonable number of inspection visits or outings of this nature. Nothing is more deadly to the success of Sections work than a repu-

tation for dry and uninteresting meetings or "cake without the frosting."

The efficacy of eye-appeal cannot be denied. Demonstrations, exhibits of specimens and working models and the graphic presentation of ideas by photographs, charts and similar adjuncts invariably add to the attractiveness of a presentation and serve to drive home the points of marked interest. The success of many of our Sections Meetings, and of our National Meetings as well, is largely attributable to these visual reinforcements.

#### Committee Meetings at French Lick Springs

**A**T meetings of national scope it is possible by holding numerous committee meetings to effect a great saving of time and funds for those who would otherwise have to make special trips for committee sessions. There is always a difficulty, however, in arranging the schedule of events at the Semi-Annual Meeting so as to avoid conflict between engineering sessions and committee conferences. With this in mind, special effort is being made to avoid such complications at French Lick Springs in June.

In due course the members of committees that are scheduled to convene during the Summer Meeting will receive notification of the plans. They are urged to make every effort to attend and to come prepared to discuss effectively the important matters at hand. Only through adequate representation and careful application to detail can the various committees serve the Society membership most successfully.

#### S.A.E. Handbook to Be Mailed This Month

**M**EMBERS will receive, during the first 2 weeks of May, copies of the March, 1926, issue of the S.A.E. HANDBOOK, the first to be printed as a complete bound volume. With the publication of this issue it becomes unnecessary for members, to keep their handbooks up-to-date, to insert new and superseding data sheets and to check the collation periodically.

The need of authoritative information in convenient form as to the sources of supply of parts and materials fabricated according to S.A.E. specifications has become increasingly apparent during the last few years. The financing of the bound volume by carrying a limited amount of advertising has made it possible to issue such an index. It is believed the index will aid in extending the use in practice of the S.A.E. Specifications.

Advertising in the S.A.E. HANDBOOK is limited to announcements of companies in a position to supply S.A.E. Standard Parts and Materials, these being defined as parts made in accordance with the existing S.A.E. Specifications that determine the dimensions necessary to allow interchangeability, and materials that conform to existing S.A.E. Specifications. Each company advertising in the March issue of the S.A.E. HANDBOOK has filed with the Society a certificate signed by the chief engineer specifying the parts or materials that his company is in a position to supply in accordance with the S.A.E. Specifications. Only these products are advertised in the S.A.E. HANDBOOK or listed in the Index to Advertisers' Products.

Under the rules of the Society, copies of this issue of the S.A.E. HANDBOOK cannot be sent to members delinquent in payment of current dues.



## AUTOMOTIVE RESEARCH

The Society's activities as well as research matters of general interest are presented in this section

### UNIVERSITY LABORATORY RESEARCH

#### Projects Contemplated or Under Way at Various Institutions of Learning

If you have no problems in your business, if you are perfectly satisfied with your product, your processes and your costs in all respects, if you have no troubles from competition or other sources of worry and are sure you are not going to have any for years to come, then you *may* not need research.

From the above statement made by C. F. Kettering, general director, General Motors Corporation Research Laboratories, it is very evident that he anticipates that the automotive industry cannot progress without research. Through the medium of the various technical and trade publications it has been easy to follow the trend of industrial research, but on the other hand little has been published that indicates the part that the university research laboratory plays in helping the automotive industry solve some of its problems. In view of the Research Department's endeavor to keep track of the work that is being done at the various institutions of learning throughout the Country, these schools were requested to furnish the Department with information concerning their activities along research lines as well as the development of any special apparatus. A description of the research work contemplated or in progress by these research laboratories follows.

#### MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Department of Aeronautics is planning to carry on in the immediate future research work on several problems connected with internal-combustion engines. Of these problems work is being planned on the following:

- (1) Investigation of the effects of supercharging under a wide variety of running conditions
- (2) Investigation of the laws governing the cooling of internal-combustion engine cylinders by direct air or air-cooling
- (3) Detailed comparison of a water-cooled and an air-cooled cylinder of otherwise similar design under a wide variety of operating conditions
- (4) Determination of scale effect on performance in a group of similar cylinders of different sizes

The tests under (1) include (a) engine capacity and efficiency when supercharging to a definite compression-pressure, with various expansion-ratios, (b) effect of various methods of supercharging on carburetion and distribution, (c) effect of supercharging on acceleration and flexibility, and (d) relative effect of pulsating and constant-pressure supercharging. During all those tests very complete data on heat balance and air consumption will be obtained in addition to the usual measurements. Apparatus is being set up for this work, but the actual experiments have not been started. Preliminary work is to be done on a single-cylinder engine with later verification on multiple-cylinder engines.

Under (2) will be included (a) quantitative measurement of heat dissipation from the various parts of the cylinder, (b) heat-transfer coefficients for various cylinder materials, (c) experimental determination of the laws governing the design and arrangement of cooling fins, (d) effect of engine cowling, (e) potential cooling efficiencies especially as compared with water-cooled engines under similar conditions, and (f) determination of temperatures of various parts of cylinder and piston under various conditions.

The tests to be conducted under (3) include (a) power and efficiency; (b) temperatures; (c) heat balance; (d) ability to operate with high compression; (e) speed limitations; and (f) altitude performance.

The apparatus for problems (2), (3) and (4) is not yet available but it is hoped that it will be forthcoming in time to start one or more of these problems at the beginning of the next college-year. The principal apparatus in this connection will be a single-cylinder crankcase designed to mount a wide variety of cylinders and to allow a rapid adjustment of compression-ratio and timing, as well as make other changes.

No special apparatus has been developed for these tests as yet but it is entirely possible that, as the work progresses, it will be found necessary to build such equipment.

The work outlined will be conducted by the laboratory staff but it is planned to make available as much apparatus as possible for experimental theses by graduate and undergraduate students. The work taken up in these theses will be of such nature as to furnish useful data to the automotive industry regarding fundamental problems in internal combustion. It is planned to have at least one electric dynamometer with very complete instrumental equipment available for this purpose exclusively.

#### NEW YORK UNIVERSITY

With the construction of a new building, which it is thought will be completed by October of this year, the new Daniel Guggenheim School of Aviation of the College of Engineering, New York University, expects to have unequalled facilities for experimental and research work in aeronautics.

A huge wind-tunnel in which an airstream having the maximum velocity of 100 m.p.h. can be produced by a propeller 16 ft. in diameter driven by a 250-hp. motor is a feature of the equipment. The Daniel Guggenheim laboratories will be utilized for research in the field of aeronautics, where every new development seems to bring further problems in view; as well as to carry out its primary function, which is to instruct students in the theory and practice of aeronautical engineering.

#### POLYTECHNIC INSTITUTE OF BROOKLYN

Realizing that many elements of difficulty still remain to be solved in the progress of carburetion, the Polytechnic Institute of Brooklyn, N. Y., under the direction of Prof. W. J. Moore, has been conducting some research in this connection.

With the aid of an exhaust-gas analyzer, known as the Mono Duplex gas-recorder, manufactured in Germany and handled in this Country by the C. G. Tagliabue Mfg. Co., graphic records were made of the performance of different carbureters to show the effect of variation of needle setting on economy. It was found for instance that a very definite relation exists between the taper of the needle on the carburetor of a Ford car and the number of gallons of gasoline used in a year. The adjustment of a carburetor being a primary feature, it was suggested that some form of the vernier scale should be incorporated in this adjustment to make possible a finer adjustment than can probably be made under present circumstances. One conclusion reached was that all carbureters should have automatic, thermostatic control of the needle-setting.

Many tests have been made of the so-called fuel dopes with the exhaust-gas analyzer, with the result that the reduction of combustibles remaining in the exhaust gas appears to be due entirely to carburetor settings and performance

and that the fuel dopes do not change the percentages.

Tests of carbon removers indicate that they tend to increase the deposit rather than to eliminate it and in some cases show a strong tendency to remove metal from the cylinder-head as well.

Another investigation that has proved fruitful is that of the resistance of spark-plugs to preignition. It has usually been thought that preignition is caused by carbon but it was found in the tests referred to that the length of the shank below the threaded portion is a big factor; also, the exposed length of the center electrode, as well as the diameter of wire, is important.

#### OHIO STATE UNIVERSITY

Experimental work has been completed at Ohio State University on a project having to do with the effects of multiple ignition. Further work is being held up due to certain limitations of equipment but it is hoped to have the results ready for publication by fall.

A new device for obtaining indicator diagrams from high-speed multiple-cylinder engines has recently been announced. A demonstration of this device will be given at the Semi-Annual Meeting to be held at French Lick Springs, Ind.

Work is about to start on a project connected with the torsional vibration of crankshafts. One of the problems is to find out the effects of varying the thickness of crank cheeks. A chassis testing dynamometer is partially erected in the laboratory and some special testing instruments will, it is hoped, be developed for use on the dynamometer when it is ready for operation.

A Foos solid-injection oil-engine is being installed which will give an opportunity to study this type of engine.

The University may possibly obtain a small universal test-engine and in this event work may be continued on the effects of multiple ignition as well as on other studies of a similar nature. The possibility of using such a unit in fuel and modified-cycle investigations as well as trying various ideas for an injection engine is being considered.

#### PURDUE UNIVERSITY

The automotive division of the Purdue University Engineering Experiment station has been in operation since 1917 under the supervision of Prof. G. A. Young. Confining its efforts to carbureter, tractor and internal-combustion engine research, it has developed highly specialized testers for the investigation of carbureters, carbureter orifices, tractors, and pistons, in addition to its general engine-dynamometer equipment.

The carburetion investigations are still in progress. Copies of bulletins giving the results obtained thus far can be procured on application to the director of the Engineering Experiment Station, West Lafayette, Ind. A list of the bulletins on the subject of carburetion that are available follows:

- Bulletin No. 5—The Carburetion of Gasoline
- Bulletin No. 11—Effect of Speed on Mixture Requirements
- Bulletin No. 15—Temperature Requirements of Hot-Spot Manifolds
- Bulletin No. 17—Car Carburetion Requirements
- Bulletin No. 21—Commercial Carbureter Characteristics

The tractor research has been of a commercial nature. The tractor-testing plant was designed to measure the internal mechanical power-losses in tractors.

The engine research was undertaken to determine the design factors that limit the permissible compression-pressure of an engine operating on the Otto cycle. As a result of the engine research, a detailed investigation of piston design was undertaken, with a view to establishing the best distribution of metal in the piston for satisfactory cooling with low weight. The principles thus determined are given in Bulletin No. 25, entitled Flow of Heat in Pistons.

Further research now in progress consists of fundamental studies of the discharge of liquids through orifices and the flow of air through venturi tubes, as a contribution to carbureter design data.

Present engine research involves the development and calibration of a positive-displacement air-meter for measuring the rate of air consumption, the study of inlet-manifold design and the determination of the effect of supercharging upon engine performance. In addition to these activities, studies in connection with mechanical atomization and combustion of liquid fuels and high-duty automotive steam power-plants are in progress.

#### YALE UNIVERSITY, SHEFFIELD SCIENTIFIC SCHOOL

A series of motor-truck tests has been made recently at the request of the Connecticut State Highway Commission to obtain the engine power-output and proportion of power lost in transmission. The purpose of these tests was to obtain complete laboratory data as well as service records of the various types of truck used by the State.

The measuring of the internal-friction losses was accomplished by the removal of the engine and substitution of a cradle dynamometer coupled to the propeller-shaft. In some cases the engine was not removed but the dynamometer was coupled directly to the crankshaft, driving through the latter with cylinder-heads removed. In either case an initial tare on the dynamometer was obtained when running in neutral gear with transmission at rest. This tare was subtracted from a final reading when driving the transmission under various load-conditions, giving a net input on the dynamometer.

The net input at the dynamometer was transferred by computation to an equivalent force acting at the rear-tire circumference, taking into account the gear-ratio, dynamometer arm and rear-wheel radius. The computed input exceeded the output at the rear-tire circumference, which was measured directly by an absorption dynamometer on the drum shaft. The difference in input and output was a measure of the loss by transmission friction plus loss in the tires. The latter was measured separately by the difference of the torque required to roll the tires, first under load, and then resting lightly on the drums.

After obtaining the input, output and tire loss, all in pounds at the rear-wheel circumference, the transmission loss was determined by the difference. The percentage of transmission loss was found by dividing the transmission loss by the input times 100. The efficiency was defined as 100 minus the percentage of transmission loss.

The transmission losses and efficiencies as thus defined have been determined for light trucks of 3 to 5-ton capacity, each over a considerable range of loads and speeds, and in all the different forward-gears.

It will be noted that the power lost in the tires has not been included in the transmission losses. This is deemed logical since the tires are not made by the truck builder and tire losses should not be charged to the transmission system.

The maximum horsepower was obtained by measuring the power delivered at the rear wheels of the truck and adding the power absorbed by the tires and transmission as determined by the method previously described. The horsepower determined in this way checks closely with the block-test of the engine, assuming that the latter includes the entire powerplant, muffler, fan, and other parts.

A new optical indicator designed by Professor Lichty will be given a trial this spring. One of these instruments was built last year for use in hydrogen explosions and proved to be exceedingly quick in its response to pressure variations. This indicator is of the diaphragm type, designed to have a very low natural time-period of vibration. By a system of knife-edges, beam and mirror, the movement of the diaphragm is magnified about 1000 times. The beam carrying the mirror is held on the knife-edges by a piano wire stretched nearly to its elastic-limit. Connection between the diaphragm and the cylinder is made by a pipe filled with a liquid of low compressibility. The timing mechanism between engine and indicator is such that a dozen or more separate and consecutive pressure-rises can be photographed on a single film, the object being to study the rate and manner of pressure-rise in internal-combustion engines.

## STANDARDS COMMITTEE DIVISION REPORTS

The following Division Reports will be submitted to the Standards Committee for approval at the Summer Meeting

### STANDARDS COMMITTEE MEETING JUNE 1

#### To Be Held at French Lick Springs during the Summer Meeting of Society

The 1926 Semi-Annual Meeting of the Standards Committee will be held on Tuesday, June 1, during the Summer Meeting of the Society at French Lick Springs. Thirty-seven reports will be submitted for disposition by 14 Divisions of the Standards Committee, these reports being printed in full in this issue of THE JOURNAL in order that those interested may review them before the meeting. The Standards Committee Meeting will start at 5 p.m., a dinner meeting being scheduled instead of the usual morning or afternoon session. It is expected that it will be possible for Committee action to be taken on all reports awaiting consideration before adjournment will be necessitated by the evening session. If it is impossible to complete the work before adjournment, an adjourned dinner meeting will be held on the following evening.

Standards Committee Meetings are open to members or non-members of the Standards Committee or of the Society, being in the nature of public hearings. Written discussion received will be submitted at the meeting. In order that adequate arrangements may be made for the dinner, members planning to attend the Standards Committee Meeting should sign Standards Committee Dinner Meeting reservation blanks when registering.

The recommendations approved by the Standards Committee will, in accordance with the Standards Committee Regulations, be submitted to a letter ballot of the voting members of the Society before becoming official S.A.E. Specifications.

### ARMY-NAVY STANDARDS APPROVED

#### Reprinting of Aeronautic Standards Adopted by Army-Navy Air Services Favored

As the Government is practically the only purchaser of aircraft, the Aeronautic Division has recommended reprinting in the S.A.E. HANDBOOK such AN Standards as were adopted by the Joint Army-Navy Air Service Conferences held in 1924 and 1925 at which the Aeronautic Division was represented. The purpose of the conferences was to eliminate the differences in the specifications and requirements for the standard aircraft parts used by the Army and the Navy. The advantages of this procedure will be appreciated by those who have, in the past, been obliged to carry duplicate stocks of so-called standard aircraft parts, necessitated by slight differences in the Army and Navy requirements.

It is not intended that the new AN Standards shall render the existing Army and Navy Standards immediately obsolete. In practically all cases the old and the new standards are interchangeable, or the old can be readily converted to the new by minor modification. When it is impracticable to make the conversion, the Army and Navy will accept parts conforming to the old standards until the supply on hand is exhausted. Manufacturers of standard parts will receive waivers on orders calling for the new standards so that they may deliver material conforming to the old standards when it is shown that the material was manufactured before the promulgation of the AN Standards. It is desired, however, that new parts, made after such promulgation, be in accordance with the AN Standards.

At the June, 1925, Meeting of the Standards Committee specifications adopted at the 1924 Conference were approved for publication in the S.A.E. HANDBOOK. Shortly before publication, however, changes in these specifications were made at the 1925 Conference and they were withheld consequently from publication. Since that time the Division has reviewed the AN Specifications given in the accompanying list and has recommended that they be printed in the S.A.E. HANDBOOK as AN Standards.

#### AN STANDARDS ISSUED BY ARMY AND NAVY AIR SERVICES

AN-3 to AN-10 inclusive Hexagon Bolts  
AN-42 to AN-49 inclusive Eye Bolts  
AN-100 Thimbles  
AN-115 Shackles  
AN-130 Cable-Eye and Fork Turnbuckle Assembly  
AN-135 Cable-Eye and Pin-Eye Turnbuckle Assembly  
AN-140 Cable-Eye Turnbuckle Assembly  
AN-155 Turnbuckle Barrel  
AN-160 Turnbuckle Fork  
AN-165 Turnbuckle Eye for Pin  
AN-170 Turnbuckle Eye for Cable  
AN-210 Pulley  
AN-310 Hexagon Castle Nuts  
AN-315 Plain Hexagon Nuts  
AN-380 Brass Cotter-Pins  
AN-392 to AN-398 inclusive Flat Head Pins  
AN-665 Rigid Terminals  
AN-671, AN-673 to AN-678 inclusive Streamline Tie-Rods  
AN-875 Hose Liners  
AN-970 Washers  
Specifications for Eye Bolts  
Specifications for Hexagon Bolts  
Specifications for Castle and Plain Hexagon Nuts  
Specifications for Flat-Head Pins  
Specifications for Shackles  
Specifications for Rigid Terminals  
Specifications for Turnbuckles

### WOOD-SPOKE SPECIFICATIONS CANCELLED

The Axle and Wheels Division has recommended that the present S.A.E. Specifications for Wood-Spokes for Passenger-Car and Motor-Truck Wheels, pp. F1 and F1a of the S.A.E. HANDBOOK, be cancelled as they no longer represent current practice owing to the development of balloon-tire equipment. These specifications were adopted in 1918 after having been endorsed by the Automobile Wood Wheel Manufacturers Association. Until the development of balloon-tire equipment, practice was in complete agreement with these specifications.

### SOLID-TIRE FELLOE AND FELLOE-BANDS

#### Present Standard Revised and Extended by the Axle and Wheels Division

The present S.A.E. Standard for Felloe-Bands, printed on p. F1g of the S.A.E. HANDBOOK, does not include the width and thickness of the felloe and felloe-band. Wheel manufacturers have found it necessary recently to make the felloe and felloe-band width the same as the nominal tire width,

previous practice having been to make this width  $\frac{3}{4}$  in. less. The Division, therefore, believes that the present standard should be extended to indicate this change in practice. The present specifications extended as proposed follow:

#### SOLID-TIRE FELLOES AND FELLOE-BANDS

Edges of felloe-bands and steel felloes shall have a radius not exceeding  $\frac{3}{32}$  in.

In measuring circumferences of felloe-bands, if the tape thickness is not allowed for in the tape-line itself, an allowance should be made amounting to three times the tape-line thickness.

#### ALLOWABLE TOLERANCES

	Tolerances, In.	
	Plus	Minus
Band Circumference before Application...	$\frac{1}{16}$	0
Band Circumference after Application to Wood Wheels and Circumference of Steel Wheels.....	$\frac{1}{16}$	$\frac{1}{32}$
Width of Band	$\frac{1}{32}$	$\frac{1}{32}$
Thickness of Band	0.006	0.006
Radius of Band after Application	$\frac{1}{16}$	$\frac{1}{16}$

The circumferential deviation from the precise figure shall be uniform across the entire width of the felloe-band.

Radial deviations shall not occur at diametrically opposite points, and there shall be no flat spots in the band on the finished wheel. Either side of the band when laid on a surface plate shall not vary more than  $\frac{1}{32}$  in. at any point.

All measurements of wheel circumferences should be made with approved standard wheel tapes such as are furnished by the Tire and Rim Association.

#### WOOD AND METAL SOLID-TIRE FELLOE-BAND DIMENSIONS

Type of Wheel	Nominal Tire Widths, In.	Width of Felloe and Band, In. $\pm \frac{1}{32}$	Felloe-Band Thickness, In. $\pm 0.006$	Felloe Thickness, In. $\pm \frac{1}{8}$
Single	3	3	$\frac{1}{4}$	$1\frac{1}{2}$
	$3\frac{1}{2}$	$3\frac{1}{2}$	$\frac{5}{16}$	$1\frac{1}{2}$
	4	4	$\frac{5}{16}$	$1\frac{1}{2}$
	5	5	$\frac{3}{8}$	2
	6	6	$\frac{3}{8}$	2
Giant Singles for Dual	7	7	$\frac{3}{8}$	2
	8	8	$\frac{3}{8}$	2
	10	10	$\frac{3}{8}$	2
	12	12	$\frac{3}{8}$	2
Dual	14	14	$\frac{3}{8}$	2
	3	6	$\frac{3}{8}$	2
	$3\frac{1}{2}$	7	$\frac{3}{8}$	2
	4	8	$\frac{3}{8}$	2
	5	10	$\frac{3}{8}$	2
Dual	6	12	$\frac{3}{8}$	2
	7	14	$\frac{3}{8}$	2

#### ROLLER-BEARING STANDARD ADOPTED

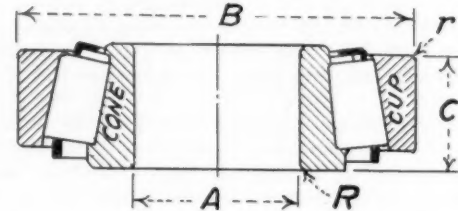
##### Report Submitted by Subdivision on Roller Bearings Eliminates over 300 Sizes

At the January, 1926, Meeting of the Standards Committee, T. V. Buckwalter, of the Timken Roller Bearing Co., presented a progress report for the Ball and Roller Bearings Division covering the work of the Subdivision on Roller Bearings, consisting of G. H. Adams, of the Bock Bearing Co., and Mr. Buckwalter. Copies of the report were dis-

tributed at the meeting. Subsequent to the Standards Committee Meeting this report was referred to manufacturers of automotive apparatus with the suggestion that the dimensions proposed be checked to current practice and suggestions or criticisms be submitted to the Society for consideration by the Division when taking final action on the report.

As a result of this circularizing several builders of passenger cars and motor trucks questioned the omission of certain roller-bearing sizes that were used by them as standard equipment. At the meeting of the Ball and Roller Bearings Division in New York City on April 20, R. M. Riblet, representing T. V. Buckwalter, and G. H. Adams reported in this connection that all bearings that have been produced in the past for the automotive industry will continue to be manufactured until the automotive manufacturers can see their way clear to adopt the S.A.E. Standard sizes and that stocks of all service sizes that are not listed in the proposed S.A.E. Standard will be carried by taper roller-bearing manufacturers until such time as no further demand for them exists. Capacities, cup and cone widths, bearing tolerances, and other such dimensions will be specified in the manufacturers' data sheets, but it is not deemed advisable to include internal dimensions in the S.A.E. Standards.

#### PROPOSED S. A. E. STANDARD FOR TAPER ROLLER BEARINGS ARRANGED ACCORDING TO BORE



A		B	C	R	r	Bearing Number	Metric Size	
Fraction	Decimal							
$\frac{5}{8}$	0.6250	1.8504	0.5662	$\frac{1}{16}$	$\frac{1}{16}$	05062-05185		
	0.6250	1.9380	$\frac{29}{32}$	$\frac{1}{32}$	$\frac{1}{16}$	09062-09194		
	0.6950	1.9380	$\frac{29}{32}$	$\frac{3}{32}$	$\frac{1}{16}$	09070-09194		
	0.7500	1.9380	$\frac{29}{32}$	$\frac{1}{16}$	$\frac{1}{16}$	09074-09194		
	0.7475	1.9380	$\frac{15}{16}$	$\frac{1}{16}$	$\frac{1}{16}$	09075-09194		
	0.7475	1.9380	$\frac{15}{16}$	$\frac{1}{16}$	$\frac{1}{16}$	09076-09194		
	0.7500	2.2400	0.7625	$\frac{1}{16}$	$\frac{1}{32}$	1775-1729		
	0.7500	2.1250	$\frac{7}{8}$	$\frac{1}{16}$	$\frac{3}{32}$	21075-21212		
	0.7870	1.8504	0.5662	$\frac{1}{16}$	$\frac{1}{16}$	05079-05185	204	
	0.7874	2.0470	0.5910	$\frac{1}{16}$	$\frac{1}{16}$	07079-07204	304	
$\frac{15}{16}$	0.8125	2.4375	$1\frac{1}{8}$	$\frac{1}{32}$	$\frac{1}{16}$	3660-3620		
	0.8750	2.2400	0.7625	$\frac{1}{32}$	$\frac{1}{32}$	1755-1729		
	0.8750	2.3750	$\frac{15}{16}$	$\frac{1}{32}$	$\frac{1}{32}$	2380-2323		
	0.9375	2.2400	0.7625	$\frac{1}{32}$	$\frac{1}{32}$	1779-1729		
	0.9375	2.4375	$1\frac{1}{8}$	$\frac{3}{32}$	$\frac{1}{8}$	3659-3620		
	0.9375	2.3750	$\frac{15}{16}$	$\frac{3}{32}$	$\frac{1}{32}$	2381-2323		
	0.9375	2.5625	$\frac{7}{8}$	$\frac{1}{16}$	$\frac{1}{16}$	23092-23256		
	0.9835	2.0470	0.5910	$\frac{1}{16}$	$\frac{1}{16}$	07098-07204	205	
	0.9835	2.4410	0.6300	$\frac{1}{16}$	$\frac{1}{16}$	17098-17244	305	
	1	1.0000	2.3750	$\frac{25}{32}$	$\frac{1}{32}$	$\frac{1}{32}$	1986-1931	
1.0000		2.6150	$\frac{15}{16}$	$\frac{1}{32}$	$\frac{1}{32}$	2687-2631		
1.0000		2.8593	$\frac{31}{32}$	$\frac{3}{32}$	$\frac{1}{16}$	41100-41286		
1.0000		2.8593	$1\frac{1}{16}$	$\frac{1}{32}$	$\frac{1}{8}$	3189-3120		
1.0000		3.1562	$1\frac{1}{16}$	$\frac{1}{32}$	$\frac{1}{8}$	338-3320		
1.0000		2.3750	$\frac{15}{16}$	$\frac{1}{32}$	$\frac{1}{32}$	2382-2323		
$1\frac{1}{16}$		1.0625	2.8593	$\frac{31}{32}$	$\frac{3}{32}$	$\frac{1}{16}$	41106-41286	
$1\frac{1}{8}$		1.1250	2.3750	$\frac{29}{32}$	$\frac{1}{32}$	$\frac{1}{32}$	1985-1931	
1.1250		2.8345	0.7480	$\frac{1}{16}$	$\frac{1}{16}$	26112T-26283		
1.1250		2.615	$\frac{15}{16}$	$\frac{1}{32}$	$\frac{1}{32}$	2689-2631		
$1\frac{1}{2}$	1.1250	3.1250	1	$\frac{1}{32}$	$\frac{1}{16}$	43112-43312		
	1.1250	2.5625	$\frac{7}{8}$	$\frac{1}{16}$	$\frac{1}{16}$	23111-23256		
	1.1562	2.6150	$\frac{15}{16}$	$\frac{1}{16}$	$\frac{1}{16}$	2690-2631		
	1.1805	2.4410	0.6300	$\frac{1}{16}$	$\frac{1}{16}$	17118-17244	206	
	1.1805	2.8345	0.7480	$\frac{1}{16}$	$\frac{1}{16}$	26118-26283	306	
	1.1810	2.7170	$\frac{25}{32}$	$\frac{9}{64}$	$\frac{1}{8}$	14117-14274		
	1.1810	2.8380	$\frac{27}{32}$	$\frac{1}{32}$	$\frac{3}{32}$	14118-14283	306	
	$1\frac{1}{8}$	1.1875	3.1495	0.8270	$\frac{1}{16}$	$\frac{1}{16}$	28118-28315	

## STANDARDS COMMITTEE DIVISION REPORTS

413

## PROPOSED S. A. E. STANDARD FOR TAPER ROLLER BEARINGS ARRANGED ACCORDING TO BORE (Concluded)

A		B	C	R	r	Bearing Number	Metric Size
Fraction	Decimal						
1 1/4	1.1875	2.7500	1 1/16	3/32	1/16	2558-2523	
	1.1875	2.8593	1 1/16	3/64	1/8	3191-3120	
	1.1875	3.1562	1 1/16	1/32	1/8	334-3320	
	1.1900	2.7170	1.0425	1 1/64	3/16	14120-14273	
	1.2500	2.7170	2 5/32	9/64	1/8	14125-14274	
	1.2500	2.7500	1 1/16	1/32	1/16	2580-2523	
	1.2500	2.7500	1 1/16	9/64	1/16	2582-2523	
	1.2500	2.8593	1 1/16	3/64	1/8	3193-3120	
	1.2500	3.1250	1	1/16	1/16	43125-43312	
	1.2500	3.1562	1 1/16	1/32	1/8	346-3320	
	1.2500	3.7500	1 1/32	1/32	3/32	443-432	
	1.2600	2.8345	0.7480	1/16	1/16	26126-26283	
1 1/8	1.3125	2.7170	2 5/32	1/32	1/8	14131-14274	
1 1/8	1.3125	2.8345	0.7480	9/64	1/16	26131-26283	
	1.3125	2.7500	1 1/16	1/16	1/8	2581-2523	
	1.3125	3.0000	1 1/16	9/64	1/8	2785-2720	
	1.3125	3.1250	1	9/64	1/16	43131-43312	
	1.3125	3.1250	1 5/32	9/64	1/8	3477-3420	
	1.3750	3.0000	1 1/16	13/64	1/8	2786-2720	
	1.3750	3.0000	1 1/16	1/16	1/8	2787-2720	
	1.3750	3.1562	1 1/16	1/32	1/8	335-3320	
	1.3750	3.1250	1 5/32	9/64	1/8	3478-3420	
	1.3750	3.1250	1 5/32	1/32	1/8	3478T-3420	
	1.3750	3.1562	1 5/32	9/64	1/8	3379-3320	
	1.3750	3.4843	1 1/16	1/32	1/32	417-414	
1 1/2	1.3750	3.7500	1 1/32	1/32	3/32	449-432	
	1.3770	2.8345	0.6700	1/16	1/16	19138-19283	207
	1.3770	3.1495	0.8270	1/16	1/16	28138-28315	307
	1.3779	3.1496	0.8268	1/32	1/32	339-333	307
	1.4375	3.1250	1 5/32	1/32	1/8	3479T-3420	
	1.4375	3.4834	1	1/32	1/16	44143-44348	
	1.5000	3.1495	0.8270	1/16	1/16	28150-28315	
	1.5000	3.0000	1 5/16	9/64	1/8	2788-2720	
	1.5000	3.1562	1 1/16	1/32	1/8	337-3320	
	1.5000	3.4843	1	1/32	1/16	44150-44348	
	1.5000	3.1562	1 5/32	9/64	1/8	3381-3320	
	1.5000	3.1562	1 5/32	9/64	1/8	3381T-3320	
1 5/8	1.5000	3.4843	1 1/16	1/32	1/32	415T-414	
	1.5000	3.4843	1 1/16	9/64	1/32	418-414	
	1.5000	3.7500	1 1/32	9/64	3/32	444-432	
	1.5625	3.4843	1	1/32	1/16	44156-44348	
	1.5625	3.1562	1 5/32	9/64	1/8	3382-3320	
	1.5625	3.1562	1 5/32	9/64	1/8	3382T-3320	
	1.5625	3.4843	1 1/16	9/64	1/32	422-414	
	1.5625	3.4843	1 1/16	1/32	1/32	422T-414	
	1.5748	3.1496	0.8268	9/64	1/32	344-333	208
	1.5748	3.5480	0.9055	1/32	1/32	350-352	
	1.6250	3.1562	1 1/16	1/32	1/8	336-3320	
	1.6250	3.1562	1 5/32	9/64	1/8	3383-3320	
1 3/4	1.6250	3.4375	1 1/16	9/64	1/8	3577-3525	
	1.6250	3.4843	1	1/32	1/16	44162-44348	
	1.6250	3.8750	1 1/32	1/16	1/32	53162-53387	
	1.6250	3.7500	1 1/32	1/32	3/32	439T-432	
	1.6250	3.7500	1 1/32	9/64	3/32	447-432	
	1.7500	3.4375	1 1/16	1/32	1/8	355-3525	
	1.7500	3.4375	1 1/16	9/64	1/8	3578-3525	
	1.7500	3.8750	1 1/32	9/64	1/32	53176-53387	
	1.7500	3.7500	1 1/32	1/32	3/32	435T-432	
	1.7500	3.7500	1 1/32	9/64	3/32	438-432	
	1.7500	4.2500	1 1/32	1/32	1/32	458T-453A	
	1.7500	4.2500	1 1/32	9/64	1/8	460-453A	
1 7/8	1.7500	4.3750	1 1/2	9/64	1/8	535-532A	
	1.7716	3.3464	0.7480	1/16	1/32	358-354	209
	1.7716	3.9370	0.9842	1/32	1/32	376-372	309
	1.8125	3.4375	1 1/16	1/32	1/8	359-3525	
	1.8125	3.4375	1 1/16	1/32	1/8	3595-3525	
	1.8750	3.6718	1 1/16	1/4	1/8	3778-3720	
	1.8750	4.2500	1 1/2	9/16	1/32	463-453A	
	1.8750	4.3750	1 1/2	9/64	1/8	536T-532A	
	1.8750	4.3750	1 1/2	9/64	1/8	536-532A	
	1.8750	4.3750	1 1/2	9/64	1/8	366-363	210
	1.9685	3.5433	0.7874	1/32	1/32		

## PROPOSED S. A. E. STANDARD FOR TAPER ROLLER BEARINGS ARRANGED ACCORDING TO BORE (Concluded)

A		B	C	R	r	Bearing Number	Metric Size
Fraction	Decimal						
2	1.9685	4.3307	0.8661	1/32	1/32	396-394A	
	2.0000	3.6718	1 1/16	3/32	1/8	375-3720	
	2.0000	3.6718	1 1/16	1/32	1/8	375T-3720	
	2.0000	3.6718	1 1/16	9/64	1/8	3780-3720	
	2.0000	4.4375	1 1/16	9/64	1/8	3975-3920	
	2.0000	4.2500	1 1/32	1/32	1/32	455-453A	
	2.0000	4.3750	1 1/2	9/64	1/8	537-532A	
	2.0000	4.8750	1 1/2	1/32	1/8	555-552A	
	2.0000	4.8750	1 1/16	9/64	1/8	72200-72487	
	2.0625	3.6718	1 1/16	3/32	1/8	377-3720	
	2.1250	4.2500	1 1/32	9/64	1/8	456-453A	
	2.1250	4.3750	1 1/2	9/64	1/8	539-532A	
	2.1250	4.3750	1 1/2	9/64	1/8	539T-532A	
2 1/4	2.1650	5.3447	2 1/8	9/64	1/8	6381-6320	
	2.1650	5.5130	0.2568	1/32	1/32	78216-78551	
	2.1653	3.9370	0.8268	1/32	1/32	385-383	211
	2.2500	4.4375	1 1/16	1/32	1/8	390-3920	
	2.2500	4.2500	1 1/32	1/32	1/32	462-453A	
	2.2500	4.2500	1 1/32	1/32	1/32	462T-453A	
	2.2500	4.8750	1 1/2	9/64	1/8	5558-552A	
	2.2500	5.3447	2 1/8	11/64	1/8	6375-6320	
	2.2500	5.8750	2 1/8	9/64	1/8	6455-6420	
	2.3622	4.3307	0.8661	1/32	1/32	397-394A	212
	2.3750	4.8750	1 1/2	1/32	1/8	558-552A	
	2.4375	4.8750	1 1/2	9/64	1/8	554-552A	
	2.5000	4.4375	1 1/16	9/64	1/8	395-3920	
2 1/2	2.5000	4.4375	1 1/16	9/64	1/8	3982-3920	
	2.5000	4.7244	1.1730	1/32	1/32	477-472	
	2.5000	4.8750	1 1/2	9/64	1/8	559-552A	
	2.5000	4.8750	1 1/2	9/64	1/8	559T-552A	
	2.5000	5.5130	1.4370	1/32	1/32	78250-78551	
	2.5000	5.5130	2.5680	1/32	1/32	78251-78551	
	2.5591	4.7244	1.1730	1/32	1/32	478-472	
	2.5625	5.3447	2 1/8	9/64	1/8	6379-6320	
	2.6250	4.8750	1 1/2	9/64	1/8	560-552A	
	2.6875	4.7244	1.1730	9/64	1/32	480-472	
	2.7500	4.7244	1.1730	9/64	1/32	482-472	
	2.7500	5.0000	1 1/16	9/64	1/8	566-563	
	2.7500	5.8750	2 1/8	13/64	1/8	6454-6420	
3	2.8750	5.0000	1 1/16	9/64	1/8	567-563	
	3.0000	5.5115	1 1/16	9/64	1/8	575-572	
	3.0000	5.8750	2 1/8	9/64	1/8	6461-6420	
	3.0000	6.3750	1 1/8	9/64	1/8	755-752	
	3.0000	6.6870	2 1/8	9/64	1/8	6576-6520	
	3.2500	5.5115	1 1/16	9/64	1/8	580-572	
	3.3450	6.6870	2 1/8	9/64	1/8	6578-6520	
	3.3475	5.9090	1 3/4	9/64	1/8	749-742	5217
	3.3750	6.0000	1 1/16	9/64	1/8	596-592A	
	3.5000	6.3750	1 1/8	9/64	1/8	759-752	
	3.5000	6.6870	2 1/8	9/64	1/8	6500-6520	
	3.5000	7.5000	2 3/4	9/16	1/8	855-854	
	3.6250	6.0000	1 5/16	9/64	1/8	598-592A	
3 1/4	3.7500	6.0000	1 1/16	9/64	1/8	594-592A	
	3.7500	7.5000	2 1/4	5/16	1/8	864-854	
	3.8750	7.1250	1 1/8	9/64	1/8	779-772	
	4.0000	7.1250	1 1/8	9/64	1/8	780-772	
	4.0000	7.1250	1 1/8	9/64	1/8	780T-772	
	4.0000	7.5000	2 1/4	5/16	1/8	861-854	
	4.0000	8.3750	2 5/8	1/32	1/8	941-932	
	4.1250	7.1250	1 1/8	9/64	1/8	782-772	
	4.2500	8.3750	2 5/8	5/16	1/8	936-932	
	4.5000	8.3750	2 5/8	9/32	1/8	938-932	
	4.5000	7.5000	1 1/8	9/64	1/8	71450-71750	

\* 1-in. taper per ft.

\* 1.5-in. taper per ft.

\* 16 threads per in., right hand.

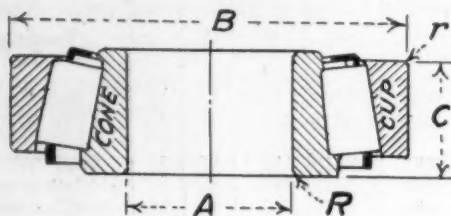
\* 16 threads per in., left hand.

\* 24-in. taper per ft.

† Double cone.

\* Chamfer.

## PROPOSED S. A. E. STANDARD FOR TAPER ROLLER BEARINGS ARRANGED ACCORDING TO BORE (Concluded)



Bearing Number	A	B	C	R	r	Metric Size
334-3320	1.1875	3.1562	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
335-3320	1.3750	3.1562	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
336-3320	1.6250	3.1562	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
337-3320	1.5000	3.1562	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
338-3320	1.0000	3.1562	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
339-333	1.3779	3.1496	0.8268	1 $\frac{1}{32}$	1 $\frac{1}{32}$	307
344-333	1.5748	3.1496	0.8268	1 $\frac{1}{32}$	1 $\frac{1}{32}$	208
346-3320	1.2500	3.1562	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
350-352	1.5748	3.5480	0.9055	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
355-3525	1.7500	3.4375	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
358-354	1.7716	3.3464	0.7480	1 $\frac{1}{16}$	1 $\frac{1}{32}$	209
359T-3525	1.8125	3.4375	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
359S-3525	1.8125	3.4375	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
366-363	1.9685	3.5433	0.7874	1 $\frac{1}{32}$	1 $\frac{1}{32}$	210
375-3720	2.0000	3.6718	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
375T-3720	2.0000	3.6718	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
376-372	1.7716	3.9370	0.9842	1 $\frac{1}{32}$	1 $\frac{1}{32}$	309
377-3720	2.0625	3.6718	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
385-383	2.1653	3.9370	0.8268	1 $\frac{1}{32}$	1 $\frac{1}{32}$	211
390-3920	2.2500	4.4375	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
395-3920	2.5000	4.4375	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
396-394A	1.9685	4.3307	0.8661	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
397-394A	2.3622	4.3307	0.8661	1 $\frac{1}{32}$	1 $\frac{1}{32}$	212
415T-414	1.5000	3.4843	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
417-414	1.3750	3.4843	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
418-414	1.5000	3.4843	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
422-414	1.5625	3.4843	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
422T-414	1.5625	3.4843	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
435T-432	1.7500	3.7500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
438-432	1.7500	3.7500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
439T-432	1.6250	3.7500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
443-432	1.2500	3.7500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
444-432	1.5000	3.7500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
447-432	1.6250	3.7500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
449-432	1.3750	3.7500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
455-453A	2.0000	4.2500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
456-453A	2.1250	4.2500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
458T-453A	1.7500	4.2500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
460-453A	1.7500	4.2500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
462-453A	2.2500	4.2500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
462T-453A	2.2500	4.2500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
463-453A	1.8750	4.2500	1 $\frac{1}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
477-472	2.5000	4.7244	1.1730	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
478-472	2.5591	4.7244	1.1730	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
480-472	2.6875	4.7244	1.1730	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
482-472	2.7500	4.7244	1.1730	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
535-532A	1.7500	4.3750	1 $\frac{1}{2}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
536-532A	1.8750	4.3750	1 $\frac{1}{2}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
536T-532A	1.8750	4.3750	1 $\frac{1}{2}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
537-532A	2.0000	4.3750	1 $\frac{1}{2}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
539-532A	2.1250	4.3750	1 $\frac{1}{2}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
539T-532A	2.1250	4.3750	1 $\frac{1}{2}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
554-552A	2.4375	4.8750	1 $\frac{1}{2}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
555-552A	2.0000	4.8750	1 $\frac{1}{2}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
555S-552A	2.2500	4.8750	1 $\frac{1}{2}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
558-552A	2.3750	4.8750	1 $\frac{1}{2}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
559-552A	2.5000	4.8750	1 $\frac{1}{2}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
559T-552A	2.5000	4.8750	1 $\frac{1}{2}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
560-552A	2.6250	4.8750	1 $\frac{1}{2}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
566-563	2.7500	5.0000	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
567-563	2.8750	5.0000	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
575-572	3.0000	5.5115	1 $\frac{1}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	

## PROPOSED S. A. E. STANDARD FOR TAPER ROLLER BEARINGS ARRANGED ACCORDING TO SERIES (Continued)

Bearing Number	A	B	C	R	r	Metric Size
580-572	3.2500	5.5115	1 $\frac{1}{16}$	9 $\frac{1}{64}$	1 $\frac{1}{8}$	
594-592A	3.7500	6.0000	1 $\frac{1}{16}$	9 $\frac{1}{64}$	1 $\frac{1}{8}$	
596-592A	3.3750	6.0000	1 $\frac{1}{16}$	9 $\frac{1}{64}$	1 $\frac{1}{8}$	
598-592A	3.6250	6.0000	1 $\frac{1}{16}$	9 $\frac{1}{64}$	1 $\frac{1}{8}$	
749-742	3.3475	5.9090	1 $\frac{3}{4}$	9 $\frac{1}{64}$	1 $\frac{1}{8}$	
755-752	3.0000	6.3750	1 $\frac{1}{8}$	9 $\frac{1}{64}$	1 $\frac{1}{8}$	
759-752	3.5000	6.3750	1 $\frac{1}{8}$	9 $\frac{1}{64}$	1 $\frac{1}{8}$	
779-772	3.8750	7.1250	1 $\frac{1}{8}$	9 $\frac{1}{64}$	1 $\frac{1}{8}$	5217
780-772	4.0000	7.1250	1 $\frac{1}{8}$	9 $\frac{1}{64}$	1 $\frac{1}{8}$	
780T-772	4.0000	7.1250	1 $\frac{1}{8}$	9 $\frac{1}{64}$	1 $\frac{1}{8}$	
782-772	4.1250	7.1250	1 $\frac{1}{8}$	9 $\frac{1}{64}$	1 $\frac{1}{8}$	
855-854	3.5000	7.5000	2 $\frac{1}{4}$	5 $\frac{1}{16}$	1 $\frac{1}{8}$	
861-854	4.0000	7.5000	2 $\frac{1}{4}$	5 $\frac{1}{16}$	1 $\frac{1}{8}$	
864-854	3.7500	7.5000	2 $\frac{1}{4}$	5 $\frac{1}{16}$	1 $\frac{1}{8}$	
936-932	4.2500	8.3750	2 $\frac{5}{8}$	5 $\frac{1}{16}$	1 $\frac{1}{8}$	
938-932	4.5000	8.3750	2 $\frac{5}{8}$	9 $\frac{32}{1}$	1 $\frac{1}{8}$	
941-932	4.0000	8.3750	2 $\frac{5}{8}$	9 $\frac{32}{1}$	1 $\frac{1}{8}$	
1755-1729	0.8750	2.2400	0.7625	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
1775-1729	0.7500	2.2400	0.7625	1 $\frac{1}{16}$	1 $\frac{1}{32}$	
1779-1729	0.9375	2.2400	0.7625	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
1985-1931	1.1250	2.3750	2 $\frac{28}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
1986-1931	1.0000	2.3750	2 $\frac{28}{32}$	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
2380-2323	0.8750	2.3750	1 $\frac{15}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
2381-2323	0.9375	2.3750	1 $\frac{15}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
2382-2323	1.0000	2.3750	1 $\frac{15}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
2558-2523	1.1875	2.7500	1 $\frac{15}{16}$	5 $\frac{32}{1}$	1 $\frac{1}{16}$	
2580-2523	1.2500	2.7500	1 $\frac{15}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{16}$	
2581-2523	1.3125	2.7500	1 $\frac{15}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{16}$	
2582-2523	1.2500	2.7500	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{16}$	
2687-2631	1.0000	2.6150	1 $\frac{15}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
2689-2631	1.1250	2.6150	1 $\frac{15}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{32}$	
2690-2631	1.1562	2.6150	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{32}$	
2785-2720	1.3125	3.0000	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
2786-2720	1.3750	3.0000	1 $\frac{15}{16}$	1 $\frac{13}{64}$	1 $\frac{1}{8}$	
2787-2720	1.3750	3.0000	1 $\frac{15}{16}$	1 $\frac{1}{16}$	1 $\frac{1}{8}$	
2788-2720	1.5000	3.0000	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
—2729	—	3.0000	1 $\frac{15}{16}$	—	1 $\frac{1}{32}$	
3189-3120	1.0000	2.8593	1 $\frac{15}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
3191-3120	1.1875	2.8593	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3193-3120	1.2500	2.8593	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3379-3320	1.3750	3.1562	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3381-3320	1.5000	3.1562	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3381T-3320	1.5000	3.1562	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3382-3320	1.5625	3.1562	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3382T-3320	1.5625	3.1562	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3383-3320	1.6250	3.1562	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3477-3420	1.3125	3.1250	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3478-3420	1.3750	3.1250	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3478T-3420	1.3750	3.1250	1 $\frac{15}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
3479T-3420	1.4375	3.1250	1 $\frac{15}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
3577-3525	1.6250	3.4375	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3578-3525	1.7500	3.4375	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3659-3620	0.9375	2.4375	1 $\frac{15}{16}$	3 $\frac{32}{1}$	1 $\frac{1}{8}$	
3660-3620	0.8125	2.4375	1 $\frac{15}{16}$	1 $\frac{1}{32}$	1 $\frac{1}{8}$	
3778-3720	1.8750	3.6718	1 $\frac{15}{16}$	1 $\frac{1}{4}$	1 $\frac{1}{8}$	
3780-3720	2.0000	3.6718	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3975-3920	2.0000	4.4375	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
3982-3920	2.5000	4.4375	1 $\frac{15}{16}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
6375-6320	2.2500	5.3447	2 $\frac{1}{8}$	1 $\frac{1}{64}$	1 $\frac{1}{8}$	
6379-6320	2.5625	5.3447	2 $\frac{1}{8}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
6381-6320	2.1650	5.3447	2 $\frac{1}{8}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
6454-6420	2.7500	5.8750	2 $\frac{1}{8}$	1 $\frac{13}{64}$	1 $\frac{1}{8}$	
6455-6420	2.2500	5.8750	2 $\frac{1}{8}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
6461-6420	3.0000	5.8750	2 $\frac{1}{8}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
6576-6520	3.0000	6.6870	2 $\frac{1}{8}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
6578-6520	3.3450	6.6870	2 $\frac{1}{8}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
6580-6520	3.5000	6.6870	2 $\frac{1}{8}$	9 $\frac{64}{1}$	1 $\frac{1}{8}$	
05062-05185	0.6250	1.8504	0.5662	1 $\frac{1}{16}$	1 $\frac{1}{16}$	
05079-05185	0.7870	1.8504	0.5662	1 $\frac{1}{16}$	1 $\frac{1}{16}$	204
07079-07204	0.7874	2.0470	0.5910	1 $\frac{1}{16}$	1 $\frac{1}{16}$	304
07098-07204	0.9835	2.0470	0.5910	1 $\frac{1}{16}$	1 $\frac{1}{16}$	205
09062-09194	0.6250	1.9380	2 $\frac{29}{32}$	1 $\frac{1}{32}$	.140	
09070-09194	0.6950	1.9380	2 $\frac{29}{32}$	1 $\frac{1}{32}$	.140	

## STANDARDS COMMITTEE DIVISION REPORTS

415

## PROPOSED S. A. E. STANDARD FOR TAPER ROLLER BEARINGS ARRANGED ACCORDING TO SERIES (Concluded)

Bearing Number	A	B	C	R	r	Metric Size
09074-09194	0.7500	1.9380	$\frac{29}{32}$	$\frac{1}{16}$	$\frac{1}{16}$	
09075-09194	0.7475	1.9380	$\frac{15}{16}$		$\frac{1}{16}$	
09076-09194	0.7475	1.9380	$\frac{15}{16}$		$\frac{1}{16}$	
14117-14274	1.1810	2.7170	$\frac{25}{32}$	$\frac{9}{64}$	$\frac{1}{8}$	
14118-14283	1.1810	2.8380	$\frac{27}{32}$	$\frac{1}{16}$	$\frac{3}{32}$	306
14120-14273	1.1900	2.7170	1.0425	$\frac{11}{64}$	$\frac{3}{16}$	
14125-14274	1.2500	2.7170	$\frac{25}{32}$	$\frac{9}{64}$	$\frac{1}{8}$	
14131-14274	1.3125	2.7170	$\frac{25}{32}$	$\frac{1}{16}$	$\frac{1}{8}$	
17098-17244	0.9835	2.4410	0.6300	$\frac{1}{16}$	$\frac{1}{16}$	305
17118-17244	1.1805	2.4410	0.6300	$\frac{1}{16}$	$\frac{1}{16}$	206
19138-19283	1.3770	2.8345	0.6700	$\frac{1}{16}$	$\frac{1}{16}$	207
21075-21212	0.7500	2.1250	$\frac{7}{8}$	$\frac{1}{16}$	$\frac{3}{32}$	
23092-23256	0.9375	2.5625	$\frac{7}{8}$	$\frac{1}{16}$	$\frac{1}{16}$	
23111-23256	1.1250	2.5625	$\frac{7}{8}$	$\frac{1}{16}$	$\frac{1}{16}$	
26112T-26283	1.1250	2.8345	0.7480	$\frac{1}{16}$	$\frac{1}{16}$	306
26118-26283	1.1805	2.8345	0.7480	$\frac{1}{16}$	$\frac{1}{16}$	
26126-26283	1.2600	2.8345	0.7480	$\frac{1}{16}$	$\frac{1}{16}$	
26131-26283	1.3125	2.8345	0.7480	$\frac{9}{64}$	$\frac{1}{16}$	
28118-28315	1.1875	3.1495	0.8270	$\frac{1}{16}$	$\frac{1}{16}$	307
28138-28315	1.3770	3.1495	0.8270	$\frac{1}{16}$	$\frac{1}{16}$	
28150-28315	1.5000	3.1495	0.8270	$\frac{1}{16}$	$\frac{1}{16}$	
41100-41286	1.0000	2.8593	$\frac{31}{32}$	$\frac{1}{16}$	$\frac{1}{16}$	
41106-41286	1.0625	2.8593	$\frac{31}{32}$	$\frac{1}{16}$	$\frac{1}{16}$	
43112-43312	1.1250	3.1250	1	$\frac{1}{32}$	$\frac{1}{16}$	
43125-43312	1.2500	3.1250	1	$\frac{1}{32}$	$\frac{1}{16}$	
43131-43312	1.3125	3.1250	1	$\frac{9}{64}$	$\frac{1}{16}$	
44143-44348	1.4375	3.4843	1	$\frac{3}{32}$	$\frac{1}{16}$	
44150-44348	1.5000	3.4843	1	$\frac{3}{32}$	$\frac{1}{16}$	
44156-44348	1.5625	3.4843	1	$\frac{3}{32}$	$\frac{1}{16}$	
44162-44348	1.6250	3.4843	1	$\frac{3}{32}$	$\frac{1}{16}$	
53162-53387	1.6250	3.8750	$\frac{17}{32}$	$\frac{1}{16}$	$\frac{1}{32}$	
53176-53387	1.7500	3.8750	$\frac{17}{32}$	$\frac{3}{64}$	$\frac{1}{32}$	
71450-71750	4.5000	7.5000	$\frac{1}{8}$	$\frac{9}{64}$	$\frac{1}{8}$	
72200-72487	2.0000	4.8750	$\frac{17}{16}$	$\frac{9}{64}$	$\frac{1}{8}$	
78216-78551	2.1650	5.5130	2.5680	$\frac{3}{32}$	$\frac{3}{32}$	
78250-78551	2.5000	5.5130	1.4370	$\frac{3}{32}$	$\frac{3}{32}$	
78251-78551	2.5000	5.5130	2.5680	$\frac{3}{32}$	$\frac{3}{32}$	

\* 1-in. taper per ft.

\* 1.5-in. taper per ft.

\* 16 threads per in., right hand.

\* 16 threads per in., left hand.

\* 2.4 in. taper per ft.

\* Double cone.

\* Chamfer.

The proposed standard, which is given in the accompanying tables, lists 174 cones and 57 cups. This represents a reduction of over 300 in the number of cones that are now being made by the roller-bearing manufacturers. Future issues of engineering data sheets printed by the makers of taper roller bearings will list only the roller-bearing sizes given in the proposed standard.

The simplification of roller-bearing sizes was first considered by the Ball and Roller Bearings Division in 1918. Owing to developments in roller-bearing design, it has been impossible for the Division to submit a final proposal until now. Although the proposed standard has been based almost entirely on current practice, some changes have been made in certain sizes that were poorly proportioned. The series proposed will meet the immediate requirements of practically all manufacturers, but it is recognized that changes in requirements owing to future developments will require revision of the proposed series.

## METRIC ROLLER BEARINGS CANCELLED

The Ball and Roller Bearings Division has recommended that the present S.A.E. Standard for Metric Roller Bearings, p. C41 of the S.A.E. HANDBOOK, be cancelled as this type of bearing has not come into general use since its adoption by

the Society in August, 1916. The Division recommendation is submitted at this time in view of the proposed adoption of the S.A.E. Standard for Inch Roller Bearings, which will meet all the requirements of the automotive industry for roller bearings.

## GENERATOR MOUNTINGS REVISED

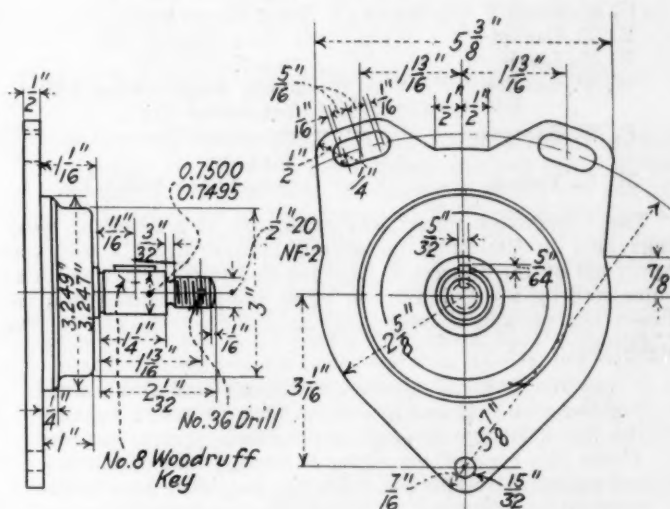
## New Bracket-Type Generator Mountings Adopted for Motorcoach Applications

The Electrical Equipment Division will submit at the June Standards Committee Meeting a complete revision of the present S.A.E. Standard for Generator Mountings printed on p. B15 of the S.A.E. HANDBOOK. The present standard, revised and extended as proposed by the Division, is given in the accompanying specifications.

## GENERATOR MOUNTINGS

Proposed S.A.E. Standard

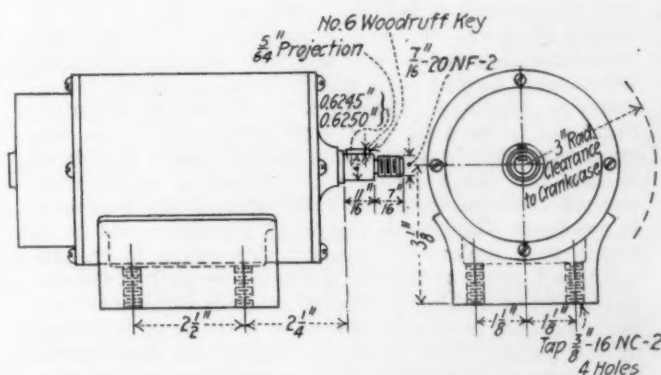
## FLANGE TYPE



## FLANGE-TYPE GENERATOR MOUNTING DIMENSIONS

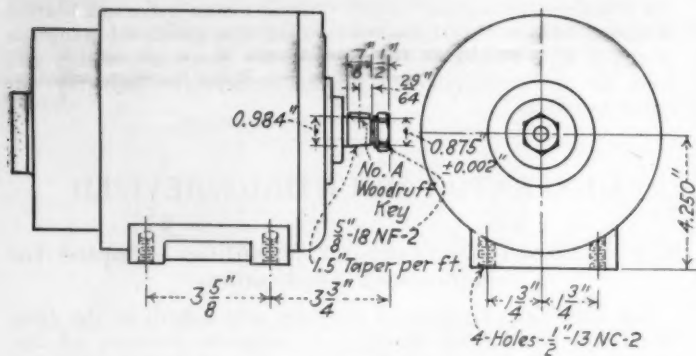
Each flange mounting size shall be provided with a pilot for locating in a bored hole when used with a gear drive and with slotted holes to allow for adjustment when used with chain drive. In the latter case the hole in the gearcase should clear the pilot.

## BRACKET TYPE



## NO. 1 BRACKET-TYPE GENERATOR MOUNTING

The generator shaft-end is suitable for all sizes of generator, except in special instances where small generators, naturally not suited to this standard, may be fitted with the S.A.E. Standard magneto shaft-end.



NO. 2 BRACKET-TYPE MOUNTING FOR MOTORCOACH GENERATORS

The report is based on the work of the Subdivision on Generator and Starting-Motor Mountings, the personnel of which is as follows:

T. L. Lee, Chairman	North East Electric Co.
W. B. Churcher	White Motor Co.
M. P. Ferguson	Eclipse Machine Co.
C. H. Kindl	Remy Electric Co.
E. T. Larkin	Sterling Engine Co.
B. M. Leece	Leece-Neville Co.
W. P. Loudon	Dayton Engineering Laboratories Co.
F. W. Sampson	Continental Motors Corporation
M. E. Toepel	International Motor Co.

The Subdivision report was drawn up as a result of meetings held in Cleveland on March 11 and April 5 and was approved by the Electrical Equipment Division on April 5 as submitted by the Subdivision. The principal differences between the present specifications and those proposed by the Subdivision are:

The No. 1 S.A.E. Flange and Shaft-End Dimensions for Generator Mountings have been cancelled because the No. 2 Flange is used in practically every instance where this type of mounting is desired and in the few instances where the No. 1 Flange has been used it has been so modified as to be hardly recognizable as an S.A.E. Standard.

The flange for the generator mounting has been changed to specify a 3-in. diameter boss so as to indicate that this space is taken up by the bearing. If the smaller-diameter boss shown in the present standard were adhered to in design, it would be necessary to mount the ball bearing some distance back from the drive gear which would be undesirable.

The present bracket-type generator mounting has been designated as the No. 1 size and a No. 2 size intended for large motorcoach generators adopted. The mounting proposed is standard with all generator manufacturers, having been widely used in recent motorcoach applications. The No. 2 S.A.E. Flange Mounting could not be used for this application because the constant vibration in motorcoach service makes it difficult to hold the flange securely to the engine unless some method of supporting the outer end of the generator is provided, which with the No. 2 Flange, would be at best a very undesirable construction owing to the adjustable feature of the No. 2 Flange as well as the impossibility of making a support accurate enough to hold the generator in exactly the same position as it is held by the flange. The flange also limits the diameter of the generator and would make it necessary to undercut the bearing in assembling. The No. 2 bracket-type of mounting is intended for motorcoach applications only.

## STARTING-MOTOR MOUNTINGS REVISED

The Electrical Equipment Division will also submit for consideration at the Standards Committee Meeting the report of the Subdivision on Generator and Starting-Motor Mountings covering revisions in the present S.A.E. Standards for Starting-Motor Mountings. The present S.A.E. specifications, revised as proposed by the Subdivision are given in the accompanying specifications. The principal changes in the S.A.E. Specifications are as follows:

The table for the starting-motor flange dimensions was extended to specify whether the installation should be for outboard or inboard mounting or both.

The illustration for the inboard installation was changed to specify a 9/16-in. dimension between the pitch-line and the rim of the flywheel.

The illustration for the outboard installation was revised to indicate the flywheel construction and the 17/32-in. dimension was changed to 9/16 in.

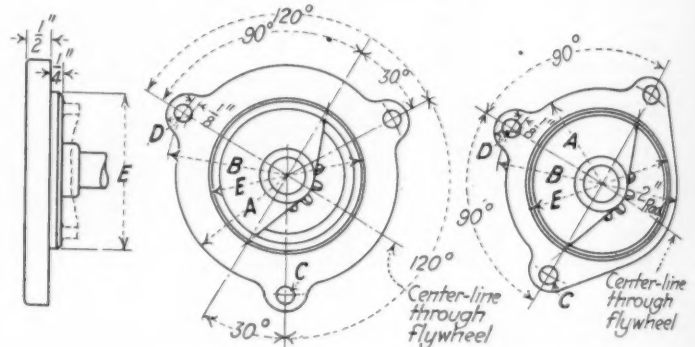
A flange-type starting-motor mounting, using a 13-tooth large shift pinion, was included for heavy-duty engines.

The illustration for the barrel-type of starting-motor mounting was revised to specify a 9/16 instead of 17/32-in. dimension for the distance from the pitch-line to the rim of the flywheel.

### STARTING-MOTOR MOUNTINGS

#### FLANGE TYPE

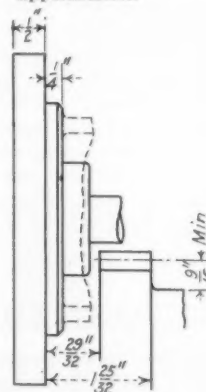
Proposed S.A.E. Standard



DIMENSIONS FOR FLANGE-TYPE STARTING-MOTOR MOUNTINGS

Size No.	Fig. No.	A	B	C	D	E		Installation
						Minimum	Maximum	
1	2	2 3/4	2 1/4	1 3/8	5/16	3.496	3.499	Outboard only
2	1	2 11/16	2 7/8	1 5/8	5/16	3.621	3.624	Inboard and outboard
3	1	2 13/16	3 1/8	1 5/8	5/16	3.621	3.624	Inboard only

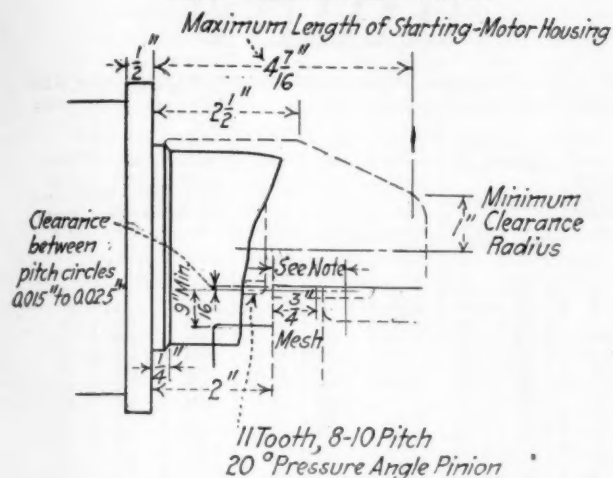
All dimensions in inches.  
Mountings may be used for either right-hand or left-hand applications.



#### INBOARD INSTALLATIONS

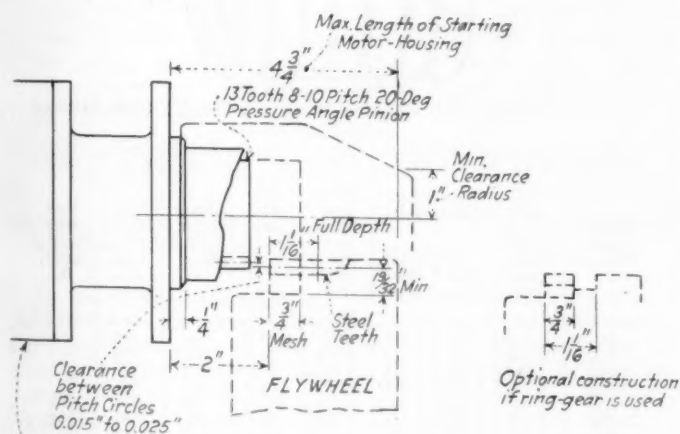
S.A.E. Standard

### OUTBOARD INSTALLATIONS S.A.E. Recommended Practice



NOTE:—When teeth are cut in the flywheel, the full depth of hobbing should be  $\frac{7}{8}$  in. If a steel ring-gear less than  $\frac{7}{8}$  in. wide is used a clearance should be provided to a depth of  $\frac{7}{8}$  in. for the pinion mesh.

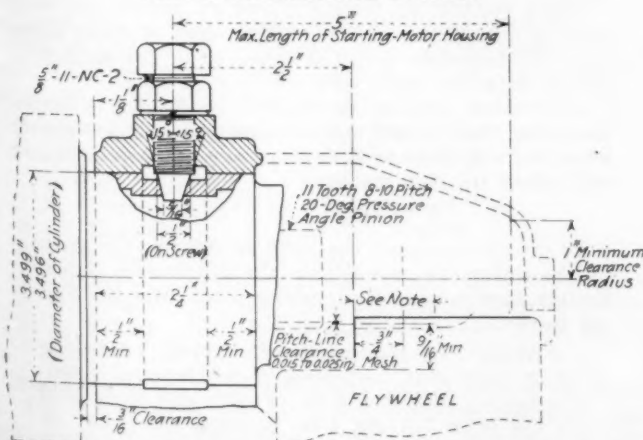
For heavy-duty engines the outboard installation shown below should be used with the No. 2 Starting-Motor Flange.



NOTE:—An additional support for the starting-motor shall be provided arranged to prevent mounting stresses

### OUTBOARD INSTALLATION FOR HEAVY-DUTY ENGINES BARREL TYPE

#### OUTBOARD INSTALLATION ONLY S.A.E. Recommended Practice



NOTE:—When teeth are cut in the flywheel, the full depth of hobbing should be  $\frac{7}{8}$  in. If a steel ring-gear less than  $\frac{7}{8}$  in. wide is used, a clearance should be provided to a depth of  $\frac{7}{8}$  in. for the pinion mesh

The limits of the bore in the flywheel housing in which the starting motor is mounted shall be 3.500 and 3.503 in.

### STARTING-MOTOR PINIONS S.A.E. Recommended Practice

Flywheel starting-motors shall be equipped with an 8-10 pitch, 11-tooth, 20-deg. pressure-angle pinion and be installed so that the pitch-circle about which the teeth of the pinion are generated will be separated by from 0.015 to 0.025 in. from the pitch-circle about which the teeth on the flywheel are generated. For starting-motors for heavy-duty engines the 13-tooth, 8-10 pitch pinion should be used.

The S.A.E. Recommended Practice for Starting-Motor Pinions, which has hitherto been printed on p. B15 of the S.A.E. HANDBOOK as a separate specification, is included in the revised report of the Electrical Equipment Division on starting-motor mountings. The present specification for an 11-tooth pinion is retained in the Division report, but a 13-tooth pinion is recommended for starting-motors intended for heavy-duty engines.

## FLEXIBLE STEEL CONDUIT PROPOSED

### Use of Salt-Spray Test for Determining Thickness of Zinc Coating Recommended

The present S.A.E. Specifications for Flexible Steel Conduit specify that the copper-sulphate method shall be used for testing the galvanizing of flexible conduit. In the last year a Subdivision of the Electrical Equipment Division has carried on extensive tests to determine the desirability of using the salt-spray test as it was found that the copper-sulphate test did not give the same weathering results as the salt-spray test. Manufacturers of steel conduit prefer the copper-sulphate test because of the speed with which it can be made, the salt-spray test requiring 24 hr., but the Subdivision believes, however, that from a user's standpoint a test is necessary that will determine how the conduit will stand up in actual service and whether or not any pin-holes exist in the coating.

The Subdivision also revised the present specifications by increasing the tensile load requirements 30 per cent and including a breaking load. As revised, the specifications are entirely satisfactory to the conduit manufacturers with the exception of the salt-spray test, but it is recognized that it will be a fairly simple matter for the manufacturers to determine a copper-sulphate test that will represent the equivalent of a 24-hr. salt-spray test. The duration of the salt-spray test was set at 24 hr. although it is felt by the Subdivision that eventually it will be possible to increase the test to 48 or 72 hr. owing to improvements in manufacturing processes.

B. M. Smarr, of the General Motors Corporation, was Chairman of the Subdivision responsible for the report, which has been approved by the Electrical Equipment Division, the other members being: C. F. Hood, of the American Steel & Wire Co.; H. J. Horn, of the John A. Roebling & Sons Co.; C. S. Hungerford, of the American Metal Hose Co.; and G. S. Wanamaker, of the National Metal Molding Co.

### FLEXIBLE STEEL CONDUIT AND TUBING GENERAL TYPES

**Flexible Steel Conduit.**—Flexible steel conduit is recommended for use as a mechanical protection to insulated electric cables that otherwise would be exposed to injury. It shall be of the square-locked type made by helically coiling a formed steel strip.

**Flexible Steel Carburetor Tubing.**—Flexible steel carburetor tubing is recommended for carburetor intakes and shall be constructed of heavier metal than flexible steel conduit. It shall be of the square-locked type made by helically coiling a formed steel strip.

**Flexible Steel Exhaust and Heater Tubing.**—Flex-

ible steel exhaust and heater tubing is recommended for use in carrying exhaust gases where a flexible connection is required and shall be constructed of heavier metal than flexible steel conduit. It shall be of the interlocked type made by helically coiling a formed steel strip.

#### GENERAL SPECIFICATIONS

**Material.**—Flexible steel conduit and tubing is made of low carbon steel strip, rust-proofed with a metallic coating before forming. Flexible steel tubing may be of either the packed or unpacked type. Packed tubing may have either asbestos or cotton packing. Asbestos packing is recommended when tubing is exposed to high temperatures, the packing consisting of a good grade asbestos yarn of a size sufficient to insure reasonable and satisfactory tightness. When packing is used merely to prevent rattles, cotton yarn is recommended.

**Diameter.**—Flexible steel conduit and flexible steel carbureter tubing are designated by the nominal inside diameter. Flexible steel exhaust and heater tubing may be designated by the nominal inside diameter, but the outside diameter must be held within the tolerances specified in Table 3.

**Length.**—When conduit or tubing is supplied in coils, all measurements for length shall be taken with the conduit or tubing fully extended. When conduit or tubing is supplied cut to length, the normal or natural lay length shall be considered. When supplied in coils, each individual length in the coil shall conform to the following:

**Conduit.**—Each length in the coil shall contain not less than 100 ft. minimum continuous length.

**Carbureter Tubing.**—Each length in the coil, from  $\frac{3}{4}$  in. to  $1\frac{1}{4}$ -in. diameter tubing, shall contain not less than 75 ft. minimum continuous length, and in sizes from 2 to 3-in. diameter the minimum continuous length shall be not less than 50 ft.

**Exhaust and Heater Tubing.**—Each length in the coil, from 1 to  $1\frac{1}{4}$ -in. diameter tubing, shall contain not less than 50 ft. minimum continuous length, and in sizes from  $1\frac{1}{2}$  to 3-in. diameter the minimum continuous length shall be not less than 40 ft.

**Workmanship.**—The interior of flexible steel conduit shall be free from burrs or sharp edges that might cause abrasion to the insulation on the cable and from obstructions that might interfere with the easy intro-



TABLE 2—FLEXIBLE STEEL CARBURETER TUBING—PACKED

Nominal Inside Diameter, In.	Actual Inside Diameter, In.		Maximum Actual Outside Diameter, In.	Minimum Thickness of Strip, in. <sup>1</sup>	Approximate Minimum Weight, Lb. per 100 Ft. Extended <sup>2</sup>	Minimum Tension Load, Lb.	Minimum Breaking Load, Lb.	Minimum Bending Radius, In. <sup>2</sup>
	Minimum	Maximum						
$\frac{3}{4}$	0.750	0.760	0.906	0.016	25.7	300	50	5
$\frac{7}{8}$	0.875	0.885	1.032	0.016	27.0	500	75	5
1	1.000	1.010	1.156	0.016	34.0	800	100	5
$1\frac{1}{8}$	1.125	1.137	1.313	0.020	37.0	850	100	$5\frac{1}{2}$
$1\frac{1}{4}$	1.250	1.262	1.448	0.020	46.0	875	110	$5\frac{1}{2}$
$1\frac{3}{8}$	1.375	1.387	1.573	0.020	52.0	890	125	$5\frac{1}{2}$
$1\frac{1}{2}$	1.500	1.512	1.698	0.020	55.0	900	140	$6\frac{1}{2}$
$1\frac{3}{4}$	1.750	1.762	1.948	0.020	64.0	925	150	$6\frac{1}{2}$
2	2.000	2.015	2.231	0.024	90.0	950	150	$7\frac{1}{2}$
$2\frac{1}{4}$	2.250	2.265	2.480	0.024	105.0	975	175	$8\frac{1}{2}$
$2\frac{1}{2}$	2.500	2.515	2.781	0.028	135.0	1,000	200	$9\frac{1}{2}$
$2\frac{3}{4}$	2.750	2.765	3.031	0.028	150.0	1,050	250	$10\frac{1}{2}$
3	3.000	3.015	3.281	0.028	165.0	1,100	300	$12\frac{1}{2}$

<sup>1</sup> These columns are for general information only.

<sup>2</sup> Inner radius of the bend without straining conduit.

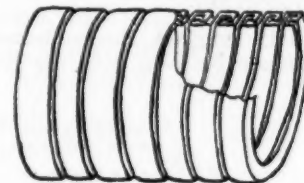


TABLE 3—FLEXIBLE STEEL EXHAUST AND HEATER TUBING—UNPACKED

Nominal Inside Diameter, In.	Minimum Actual Inside Diameter, In.	Actual Outside Diameter, In.		Minimum Thickness of Strip, In. <sup>1</sup>	Approximate Minimum Weight, Lb. per 100 Ft. Extended <sup>2</sup>	Minimum Tension Load, Lb.	Minimum Breaking Load, Lb.	Minimum Bending Radius, In. <sup>2</sup>
		Minimum	Maximum					
1	1.000	1.115	1.125	0.012	35.0	800	100	5
$1\frac{1}{4}$	1.125	1.303	1.313	0.016	48.0	850	125	5
$1\frac{1}{2}$	1.250	1.428	1.438	0.016	52.5	875	130	6
$1\frac{3}{4}$	1.500	1.678	1.688	0.016	62.5	890	145	7
2	2.000	2.235	2.250	0.020	106.0	930	175	$9\frac{1}{2}$
$2\frac{1}{4}$	2.250	2.485	2.500	0.020	118.0	950	190	$10\frac{1}{2}$
$2\frac{1}{2}$	2.500	2.735	2.750	0.020	132.5	960	210	12
$2\frac{3}{4}$	2.750	2.980	3.000	0.020	145.0	1,000	255	14
3	3.000	3.230	3.250	0.020	160.0	1,050	350	16

<sup>1</sup> These columns are for general information only.

<sup>2</sup> Inner radius of the bend without straining conduit.

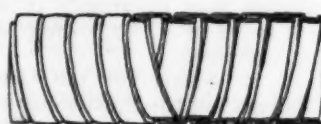
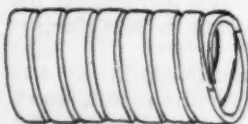


TABLE 1—FLEXIBLE STEEL CONDUIT—UNPACKED

Nominal Inside Diameter, In.	Actual Inside Diameter, In.		Maximum Actual Outside Diameter, In.	Minimum Thickness of Strip, In. <sup>1</sup>	Approximate Minimum Weight, Lb. per 100 Ft. Extended <sup>2</sup>	Minimum Tension Load, Lb.	Minimum Breaking Load, Lb.	Minimum Bending Radius, In. <sup>2</sup>
	Minimum	Maximum						
$\frac{3}{4}$	0.188	0.200	0.280	0.010	3.5	75	30	$\frac{3}{4}$
$\frac{7}{8}$	0.250	0.265	0.350	0.010	4.0	100	40	$\frac{7}{8}$
$\frac{1}{2}$	0.313	0.330	0.420	0.010	4.9	110	40	1
$\frac{3}{4}$	0.375	0.395	0.485	0.011	6.5	125	45	$1\frac{1}{4}$
$\frac{1}{2}$	0.438	0.460	0.545	0.011	7.7	150	45	$1\frac{1}{2}$
$\frac{3}{4}$	0.500	0.525	0.630	0.011	8.5	175	75	$1\frac{1}{2}$
$\frac{1}{2}$	0.562	0.587	0.692	0.011	9.5	185	75	$1\frac{1}{2}$
$\frac{3}{4}$	0.625	0.656	0.755	0.011	10.5	200	75	$1\frac{1}{2}$
$\frac{1}{2}$	0.750	0.790	0.920	0.013	14.5	300	100	2

<sup>1</sup> These columns are for general information only.

<sup>2</sup> Inner radius of the bend without straining conduit.

duction of the maximum size cable for which the conduit is normally intended.

When conduit or tubing is cut to length, the ends shall be cut square and free from burrs or sharp edges that will interfere with the assembly of the conduit or tubing with the parts with which it is used.

All conduit and tubing shall be so formed in manufacturing that it will not unravel or show loose ends when cut and shall be free from any other defects that will affect its serviceability.

#### TESTS

To insure a product that will be suitable for the conditions ordinarily met within the automotive industry, flexible steel conduit and tubing must pass the following tests:

**Tensile Test.**—A piece of conduit or tubing 12 in. long shall be placed in the jaws of a tensile testing-machine, 4 in. of each end being held by the jaws, leaving 4 in. between the jaws. A mandrel of the proper diameter shall be inserted in each end of the conduit or tubing to prevent distortion. The conduit or tubing shall show no

indication of yielding under a load less than specified in the tables.

**Breaking Test.**—A piece of conduit or tubing shall be bent to a U-shape between the flat heads of a compression testing-machine. The conduit shall be held in the machine in such a position that as the load is applied the radius of the bend shall be decreased until the yield-point is reached. The breaking load thus found shall be not less than that specified in the tables.

**Corrosion Test.**—Flexible steel conduit and tubing shall have a metallic coating that will stand a 24-hr. Bureau of Standards Salt-Spray Test without the appearance of rust on any important surface. The salt-spray test shall be conducted in a cabinet in which a solution of salt, NaCl, 20 per cent by weight, is atomized continuously so as to give a visible fog in all parts of the cabinet. The temperature should be approximately 70 deg. fahr. The pieces that are to be tested shall be free from all protective films other than the metallic coating. In case it is impossible to run the salt-spray test continuously, by agreement the piece or pieces may be washed and dried and stored in a dry place until they are placed in the cabinet for further test.

#### INSTALLATION

To protect the electric wires from abrasion, and to prevent the conduit from unwinding, all exposed free ends, when installed, should be bushed with suitable ferrules soldered to the conduit. Where taps or joints are made, suitable junction-boxes shall be used, and also the ends of the conduit entering these boxes shall be carefully bushed with ferrules.

### INSULATED CABLE STANDARD REVISED

#### Present Physical Tests Retained But Will Be Revised in Subsequent Reports

At the June, 1925, Meeting of the Standards Committee the Electrical Equipment Division submitted a report covering certain revisions in the present S.A.E. Standard for Insulated Cable, p. B33 of the S.A.E. HANDBOOK. These revisions were based on the report of the Subdivision on Insulated Cable of which F. W. Andrew was then chairman.

Owing to criticisms brought up at the Standards Committee Meeting to the effect that, as the Geer test included in the report as an alternative for the present rubber physical tests was under investigation by a committee working under the American Society for Testing Materials, no action should be taken until the report of that committee was available, the Standards Committee referred the report back to the Electrical Equipment Division with the request that it investigate this situation and report back at a later date. As a result of this action, Chairman Lee of the Electrical Equipment Division reappointed the Subdivision on Insulated Cable, the personnel being:

D. M. Pierson, <i>Chairman</i>	Dodge Bros.
F. W. Andrew	Glen Head, N. Y.
C. J. Bopp	Packard Motor Car Co.
S. R. Dresser	Whitney Blake Co.
W. S. Haggott	Packard Electric Co.
F. C. Kroeger	Remy Electric Co.
A. R. Small	Underwriters' Laboratories
B. M. Smarr	General Motors Corporation
T. E. Wagar	Studebaker Corporation of America

A meeting of the Subdivision was held in Detroit on March 4, 1926, a completely revised specification for insulated cable being submitted by Chairman Pierson for consideration. The specification was approved by the Subdivision with one dissenting vote and submitted to the Electrical Equipment Division. The report as submitted to the Division specified that

Rubber insulation used on the cables shall be of a compound to withstand the physical tests hereinafter specified

and that

The tensile-strength of the rubber insulation shall not be less than 500 lb. per sq. in., this test to be made at a temperature of not less than 50 or more than 90 deg. fahr. and not less than 48 hr. nor more than 3 months after vulcanization.

At the Division meeting it was brought out in discussion of these specifications that lowering the tensile-strength of the rubber insulation for wall thicknesses over 0.045 in. from 600 to 500 lb. per sq. in., this test to apply for a period of only 3 months, did not meet the requirement of the car builders as they were more interested in the condition of the cable 1 year after manufacture than only at the end of 3 months. The Geer test was not included in the revised report as it was found that this test alone did not assure rubber compounds that would conform to the desired physical characteristics. It was thought that if the percentage of new rubber were omitted, the physical tests should be revised to specify requirements for the tensile-strength and the elasticity based on tests made 1 year after manufacture so as to assure satisfactory life.

The reasons for omitting the percentage of rubber used in the insulation were explained as follows by Mr. Pierson, chairman of the Subdivision, in transmitting the report of his Subdivision to the Electrical Equipment Division.

I understand from a number of sources that an analysis of a rubber compound will show the percentage of rubber present in the compound, but that no positive indication is given as to whether this rubber be unused or reclaimed gum. Assuming that this is true, any specification that designates a particular percentage of a material, the presence of which cannot be proved, is based on an unsound premise. Furthermore, the physical tests as detailed will give a rather positive indication of the mechanical characteristics of the compound. Undoubtedly considerable opposition to the acceptance of this change in the specification will be encountered, but I personally, together with the almost unanimous consent of the Subdivision, feel that the performance of the cable is of more interest to the user than its analysis, particularly when that analysis will not indicate truthfully the composition of the material.

W. S. Haggott felt that it was desirable to retain the 20-per cent requirement for unused rubber as it is desirable to require a better cable than is used for general house wiring purposes and to keep low-grade compounds out of starting-motor cable. As it was recognized that the 3-month period specified did not assure sufficient cable life, the Division adopted the Subdivision report but retained the present requirements for the amount of unused rubber and the physical tests, approving the remainder of the specification as submitted by the Subdivision. The Division instructed the Subdivision, however, to submit a supplementary report covering physical-property tests that would not require specifying the amount of rubber. It is expected that this report will be available for action at the Annual Meeting of the Society and if adopted it should bring about a more general use of the S.A.E. Cable Standard owing to the more convenient form used in specifying the various types of construction.

#### REVISED S. A. E. STANDARD FOR INSULATED CABLE I. GENERAL SPECIFICATIONS

**Conductors.**—Conductors shall be bunched or stranded as specified in each section and shall be of annealed copper wire in accordance with Specification No. D3-15 of the American Society for Testing Materials. All tinned wires must withstand the tinning test as specified in Section II, Tests. All tests of copper conductors shall be made before stranding or insulating.

**Rubber Insulation.**—Rubber insulation shall be homogeneous in character, properly vulcanized and placed concentrically about the conductors. Rubber insulation

shall adhere closely to, but shall strip readily from, the conductors, leaving them reasonably clean.

Rubber insulation used on cables covered by these specifications shall contain not less than 20 per cent, by weight, of good grade Hevea rubber that has not been previously used.

**Varnished Cambric Tape.**—Varnished cambric tape shall be made from a good grade closely-woven cotton fabric with multiple coats of insulating varnish. The instantaneous puncture-voltage shall be not less than 750 volts per mil thickness tested in accordance with American Institute of Electrical Engineers Standard, Section 30—Wires and Cables.

Varnished cambric tape shall be not less than 0.005 in. thick for wires No. 10 A.w.g. and smaller. For wires No. 8 A.w.g. and larger varnished cambric tape shall be not less than 0.007 in. In no case shall it be more than 0.013 in. thick.

**Braids.**—Braids shall consist of closely-woven cotton yarn and shall not be less than 1/64 in. thick and shall be impregnated with at least two coats of properly dried heat, oil and water-resisting insulating varnish or enamel, or when specified, impregnated with black weather-proof wax compound that thoroughly saturates the braid and that has an even and smooth finish. Adjacent layers of cable when wound on the reels shall not stick to one another at any temperature under 105 deg. fahr. (40 deg. cent.)

**Armor.**—Armor shall be solid D-shaped of either galvanized or sherardized dead-soft steel, soft brass, aluminum, or copper and applied in a close helix. Successive turns shall not overlap. Armor dimensions shall be as given in Table 1.

TABLE 1—ARMOR THICKNESS AND WIDTH DIMENSIONS

Armor	Thickness, In.			Width, In.		
	Mini- mum	Nomi- nal	Maxi- mum	Mini- mum	Nomi- nal	Maxi- mum
Small....	0.014	0.017	0.020	0.045	0.050	0.055
Large....	0.017	0.020	0.023	0.095	0.100	0.105

Note:—The small sizes of armor shall be used on No. 10 A.w.g. and smaller, and the large armor on wires heavier than No. 10.

## II. TESTS

**Tinning Tests.**<sup>1</sup>—For this test, samples of the bare wire before being stranded or insulated shall be properly selected to secure an average grade of tinning. The wires shall be thoroughly cleansed by means of ether, benzine, gasoline, naphtha, alcohol, or carbon-tetrachloride, whichever may be found necessary to clean the wires thoroughly. Care shall be taken to avoid abrading or scratching the samples of wire to be tested.

The wires shall then be rinsed in clear water and wiped dry with a soft cotton cloth. The wires shall then be immersed for 1 min. in a solution of hydrochloric acid having a specific gravity of 1.088 at 70 deg. fahr. (21 deg. cent.), and then rinsed in clear water and wiped dry as above specified. The wires shall then be immersed for 30 sec. in a solution of sodium-polysulphide having a specific gravity of 1.142 at 70 deg. fahr. (21 deg. cent.), which contains an excess of sulphur. The sodium-polysulphide solution shall be maintained at a sufficient strength to blacken thoroughly a piece of clean untinned copper wire in 5 sec.

The complete cycle of operations shall then be repeated, commencing with the immersion in hydrochloric acid and ending with the immersion in the sodium-polysulphide solution.

Tests of tinning shall be made on not less than 10 sets of samples of reasonable length. All tests shall

<sup>1</sup>This test conforms substantially to that in Specification B33-21 of the American Society for Testing Materials.

be conducted with the solution at a temperature of 70 deg. fahr.

After completing the above two cycles of dips the samples of wire shall be examined to ascertain, through blackening caused by the sodium-polysulphide solution, whether the copper is exposed. The samples shall be considered to have failed if, by such blackening, the copper shall be shown to be exposed.

**Physical Tests.**—A test-specimen of rubber insulation, which has not previously been handled, not less than 6 in. long shall have marks placed upon it 2 in. apart. The sample shall then be stretched at the rate of 12 in. per min. until these marks are 6 in. apart, and then immediately released. Thirty seconds after being released the distance between the marks shall not exceed 2½ in. The test-specimen shall then be stretched until the marks are 7 in. apart before it is ruptured.

The tensile-strength of rubber insulation shall not be less than 600 lb. per sq. in. The tensile-strength shall be calculated upon the original cross-section of the test-specimen before stretching.

Physical tests shall be made at a temperature of not less than 50 deg. fahr. (10 deg. cent.), nor more than 90 deg. fahr. (32 deg. cent.).

For the purpose of these tests, care must be used in cutting to obtain samples of uniform cross-section and no manufacturer shall be responsible for results obtained from samples imperfectly cut.

The above physical tests shall not apply to wires or cables having a wall thickness of less than 0.045 in. For wires and cables having a wall thickness of less than 0.045 in. the initial and ultimate stretch shall be 5 and 6 in. respectively, and the tensile-strength not less than 500 lb. per sq. in.

**Oil Test for Braided Cables.**—This test shall be made on all cables both high-tension or secondary ignition cable and also on primary or low-tension and lighting cables that have either a varnished or enameled braid covering.

Samples of cables shall be immersed in a mixture of equal parts of engine oil and gasoline for a period of 24 hr. without allowing the ends of the sample to become submerged. After this immersion the varnish or enamel should not show signs of softening or absorption, and when the braids have been peeled off, it should be shown that no oil has penetrated to the rubber insulation. In making this test a shallow vessel shall be used to hold the mixture of engine oil and gasoline so that the sample of wire may be immersed without a sharp bend or the necessity of sealing the ends of the wire.

## III. SPECIFICATION FOR HIGH-TENSION OR SECONDARY IGNITION CABLES

The conductors shall be of tinned copper wires. High-tension or secondary ignition cables shall be one of the following constructions as specified by purchaser:

- (1) Plain rubber covered
- (2) Rubber covered and varnished cambric taped and braided
- (3) Rubber covered with single braid
- (4) Rubber covered with double braid

A weather-proof waxed braid shall not be used on this type of cable. When varnished cambric strips are used there shall be an overlap of 25 per cent when measured normal to the edge of the strip.

High-tension or secondary ignition cable sizes shall be as given in Table 2, and when braided shall be varnished or enameled to withstand the oil-test specifications for braided cables as given in Section II.

## IV. SPECIFICATION FOR LOW-TENSION OR PRIMARY IGNITION AND LIGHTING AND STARTER CABLES

Conductors shall be bunched or stranded and insulated in one of the following ways to be specified by purchaser:

## STANDARDS COMMITTEE DIVISION REPORTS

421

TABLE 2—HIGH-TENSION OR SECONDARY IGNITION CABLE SIZES

Nominal Size		Number of Wires in Strand	Nominal Size of Wires in Strand, A.w.g.	Maximum Outside Diameter, In.	Minimum Outside Diameter, In.	Minimum Thickness of Rubber Wall, In.		
Mm.	In.					Plain Rubber Covered	Single Braid	Double Braid
7	0.2756	12	26 (0.0159)	0.285	0.265	0.097	0.081	0.066
		19	27 (0.0142)					
9	0.354	19	27 (0.0142)	0.364	0.344	0.135	0.119	0.104

The 7-mm. size is recommended for all high-tension cable.

- (1) Plain rubber covered
- (2) Rubber covered and single braided
- (3) Rubber covered and double braided
- (4) Two layers of varnished cambric tape and single braid
- (5) Two layers of varnished cambric tape and double braid
- (6) Rubber covered with rubber-faced tape and single braid (for starting-motor cables only)
- (7) Rubber covered with rubber-faced tape and double braid (for starting-motor cables only)

The braid shall be varnished, enameled or weather-proof as specified in paragraph under general specifications.

Low-tension or primary ignition cable sizes shall be as given in Table 3.

TABLE 3—LOW-TENSION RUBBER INSULATED IGNITION CABLE SIZE (NOT BRAIDED)

Nominal Size	Number of Wires in Strand	Nominal Size of Wires in Strand		Maximum Outside Diameter, In.	Minimum Outside Diameter, In.
		A.w.g.	In.		
5 mm. (0.197 in.)	19	27	0.0142	0.207	0.187

Note.—The above cable is recommended as a grounding cable for short-circuiting magnetos.

TABLE 4—RECOMMENDED STRANDING AND DIMENSIONS OF LIGHTING AND STARTING CABLE

Nominal Size A.w.g.	Number of Wires in Strand	Nominal Size of Wires in Strand		Circular Mills		Continuous Carrying Capacity, Amp.	Maximum Outside Diameter, In.	Thickness of Rubber Wall, In.
		A.w.g.	In.	Nominal	Actual			
16	12	27	0.0142		2,420			
	16	28	0.0126	2,580	2,556	6	0.200	0.0310
	19	29	0.0113		2,409			
14	19	27	0.0142		3,831			
	26	28	0.0126	4,110	4,154	15	0.223	0.0310
12	19	25	0.0179		6,088			
	26	26	0.0159	6,530	6,606	20	0.250	0.0310
10	19	23	0.0226		9,679			
	49	27	0.0142	10,400	9,880	25	0.275	0.0310
8	19	21	0.0285		15,390			
	49	25	0.0179	16,500	15,700	35	0.320	0.0370
4	61	22	0.0253		39,200			
	49	21	0.0285	41,700	39,689	70	0.420	0.0468
1	127	22	0.0253		81,613			
	133	22	0.0253	83,700	85,460	100	0.600	0.0625
	127	21	0.0285		102,866			
	133	21	0.0285	106,000	107,726	125	0.635	0.0625
00	127	20	0.0319		129,723			
	133	20	0.0319	133,000	135,852	150	0.700	0.0625
	259	23	0.0226		131,936			

Note.—The total circular mil area of any strand shall not vary more than 2½ per cent from the actual figures given. Tolerances for the diameter of the rubber shall be as follows:—No. 16 to No. 10 A.w.g. inclusive, plus or minus 0.005 in.; No. 8 to No. 00 A.w.g. inclusive, plus or minus 0.010 in.

The nominal diameter of the wires in the strands and the nominal circular mil area agree with figures issued by the Bureau of Standards in Circular 31, Table VIII.

Conductors of primary lighting and starting-motor cables shall be of the sizes and construction given in Table 4.

Conductors of cables composed of No. 16 to 10 A.w.g. inclusive shall be of tinned copper wires when rubber insulation is used and may be bunched or stranded as desired.

Conductors of cables composed of No. 8 A.w.g. and larger shall be stranded and may have concentric or rope lay. In rubber insulated cables either tinned copper wires or bare copper wires with suitable separator may be used.

When low-tension lighting or starting-motor cables are insulated with varnished cambric tape and no rubber there shall be two or more layers of overlapping varnished cambric tape with the alternate layers laid in opposite directions. The overlap of each layer shall be not less than 25 per cent of the width of the cambric strip measured normal to the edge of the strip. When varnished cambric tape and no rubber is used for insulation either tinned or bare copper wires may be used as specified by the purchaser.

Note.—With reference to the paragraph dealing with the method of stranding No. 8 A.w.g. and larger under Section IV, it is the intention of these specifications to permit a combination of rope lay and concentric lay cables, inasmuch as it was pointed out that in a few instances this construction is being used in practice today.

## V. SPECIFICATIONS FOR ARMORED LIGHTING CABLES

Lighting cables of this class shall be insulated with

- (1) Two or more layers of overlapping varnished cambric tape. Alternate layers shall be laid in opposite directions. The overlap of each layer shall be not less than 25 per cent of the width of the cambric strip measured normal to the edge of the strip

- (2) Rubber insulated

- (3) Rubber insulated and varnished cambric tape

All cables under this class shall have one or two cotton braids treated in accordance with Section II.

The armor over the braid shall be in accordance with Section I and Table 1.

TABLE 5—ADDITIONAL SPECIFICATIONS FOR ARMORED LIGHTING CABLES AND FOR STARTING CABLES WITH VARNISHED CAMBRIC INSULATION

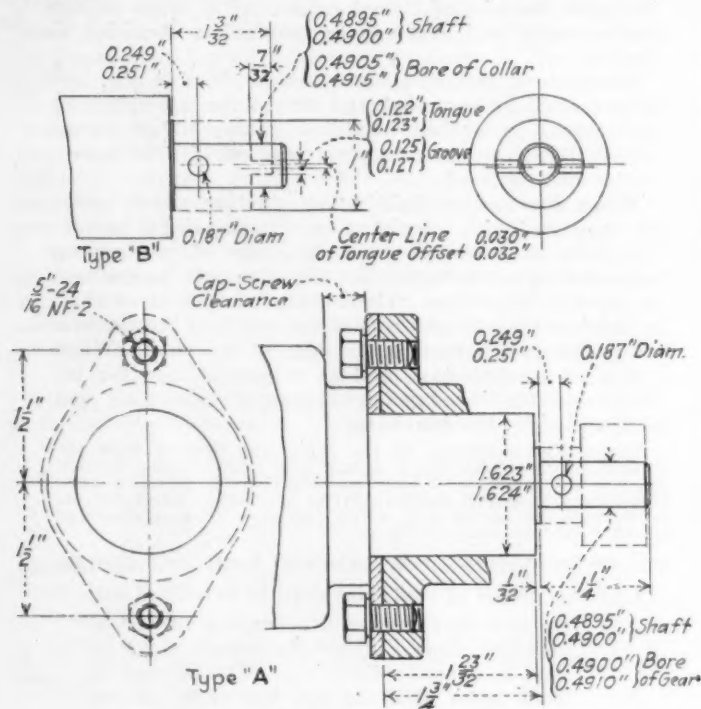
Nominal Size A.w.g.	Continuous Carrying Capacity, Amp.	MAXIMUM OUTSIDE DIAMETER, IN.	
		Varnished Cambric Cables	Armored Cables
16	8	0.215	0.255
14	18	0.229	0.269
12	22	0.249	0.289
10	27	0.273	0.313
8	45	0.298	0.338
4	80	0.383	.....
2	110	0.450	.....
1	140	0.530	.....
0	180	0.570	.....
00	210	0.629	.....

*Note.*—Armored starting-motor cables are now excluded from these standards. If metal protection is desired, it is recommended that S.A.E. Standard flexible steel conduit be used.

## HEAVY-DUTY DISTRIBUTOR DESIGNED

### Electrical Equipment Division Recommendation Intended for Motorcoach Engines

The timer-distributor mountings given in the accompanying illustrations were approved at the April meeting of the Electrical Equipment Division for adoption as S.A.E. Recommended Practice for heavy-duty service. The recommendation is based on a Subdivision report submitted by W. P. Loudon of the Dayton Engineering Laboratories Co., and T. L. Lee of the North East Electric Co. The mountings proposed are especially suitable for motorcoach and taxicab engines.



PROPOSED HEAVY-DUTY TIMER-DISTRIBUTOR MOUNTINGS

## PISTON-RING WIDTH TO BE NOMINAL

### Cancellation of Present Specification for Piston-Ring Grooves Recommended

At the meeting of the Engine Division in Chicago on April 7 it was recommended that the present S.A.E. Recommended Practice for Piston-Ring Grooves, pp. A6 and A7 of the S.A.E. HANDBOOK, should be cancelled and the following specification adopted.

The nominal piston-ring width shall be basic, the tolerances being plus 0 and minus 0.0005 in. Limits for the width of the piston-ring groove are not specified as the fits and tolerances depend on the particular conditions existing for each application.

The action of the Engine Division was based on a survey which indicated that current piston-ring practice varies with regard to the tolerances for the groove width, in some cases being over, and in others under, the nominal width. It was recognized that as piston-rings constitute a product which is distributed on a national basis for replacement as well as initial equipment, pistons being designed for each application, the nominal piston-ring width should be basic to avoid the tremendous variety of widths which would be necessary if the piston-ring tolerances were varied to suit each application. It was also realized that general adoption of the proposed

specification would reduce the cost of piston-rings as it would do away with the great variety of rings of the same nominal width. A tolerance of 0.0005 in. was specified as it was agreed that all piston-ring manufacturers could hold to this tolerance without undue hardship.

The present S.A.E. Recommended Practice for Piston-Ring Grooves has not been widely adopted by the industry, in the opinion of the members of the Engine Division, because dimensions and limits are specified that are not necessary to provide interchangeability of piston-rings.

## PISTON-RING OVERSIZES RECOMMENDED

### 0.003-In. Oversize Not Included in Revised Report of Engine Division

At the January, 1926, Meeting of the Standards Committee the Engine Division report for piston and piston-ring oversizes was referred back for reconsideration as it was felt inadvisable to specify different series of oversizes for various applications or to include the 0.003 and 0.005-in. oversizes for pistons and piston-rings.

At the last meeting of the Engine Division the report was reconsidered in view of the comments expressed at the Standards Committee Meeting, which were printed in the March, 1926, issue of THE JOURNAL, p. 253, and it was recommended that the proposed standard should be revised to read:

Standard oversizes for piston and piston-rings shall be 0.005, 0.010, 0.015, 0.020, 0.030, and 0.040 in. Larger oversizes, when necessary, shall be held to multiples of 0.010 in.

The original report submitted at the January, 1926, meeting is given hereinafter in case it is desired to review the subject.

The present S.A.E. Standard for Oversize Cylinders specifies that, in order to obtain uniform practice, cylinder oversizes of 0.010, 0.020, 0.030, and 0.040 in. should be used. The Engine Division has recommended that the following specifications supersede this standard.

Standard oversize pistons for passenger-car, motorboat and airplane internal-combustion engines shall be 0.003, 0.005, 0.010, 0.015, 0.020, and 0.030 in. The standard oversizes for motorcoach, tractor, truck and industrial internal-combustion engines shall be 0.010, 0.020, 0.030, and 0.040 in. Larger oversizes, when necessary, shall be held to multiples of 0.010 in.

Piston-rings shall be held to the same oversizes, omitting the 0.003-in. oversize, as are specified for pistons.

This report was prepared by a Subdivision of which A. W. Reader, then of the General Motors Corporation, was chairman, the other members being R. J. Broege, of the Buda Co., and A. F. Milbrath, of the Wisconsin Motor Mfg. Co. The report was submitted to passenger-car and truck builders and met with general approval prior to the final Division action.

The work on this subject was instituted as a result of a conference, held in December, 1924, under the auspices of the Division of Simplified Practice of the Department of Commerce, of piston, piston-ring and passenger-car manufacturers. In the discussion at this Conference it was brought out that certain piston-ring manufacturers find it necessary to hold 4800 sizes in stock to meet current requirements. Although it was recognized that the piston-ring manufacturers were, in a certain measure, responsible for this uneconomical situation, it was appreciated that the recognition of standard oversizes by both automobile and piston-ring manufacturers would greatly improve conditions. It was decided to refer the problem to the Society with a request that the present S.A.E. Standard be revised to specify a series of oversizes that would meet all requirements for internal-combustion engines.

At the Engine Division meeting, Mr. Milbrath, chairman of the 1926 Subdivision, submitted a summary of piston and piston-ring oversizes now in use which indicated that the majority of car builders are using the oversizes recommended by the Subdivision. The summary follows:

Piston and Piston-Ring Oversizes	Number of Manufacturers Using Oversizes
0.0020	10
0.0025	2
0.0030	8
0.0050	26
0.0075	1
0.0100	40
0.0125	1
0.0150	29
1/64	1
0.0200	40
0.0230	2
0.0250	4
0.0300	37
1/32	1
0.0350	2
0.0400	15
0.0450	2
3/64	1
0.0500	8
0.0550	1
0.0600	3
1/16	3
0.0600	13
0.1000	1
1/8	2

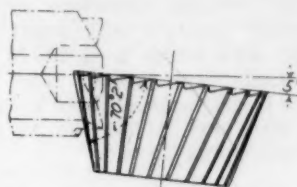
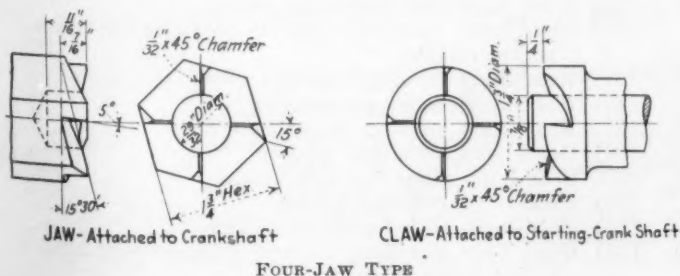
## ENGINE SUPPORT ARMS REVISED

The dimensions specified in the S.A.E. Standard for Engine Support Arms, p. A4 of the S.A.E. HANDBOOK have been criticized to the effect that they do not allow sufficient clearance between dimensions A and B, the distance from the center-line of the support arm bolt-holes to the shoulder of the support arms, to accommodate pads between the engine arms and the brackets in the Nos. 3, 4 and 5 sizes. At the Engine Division meeting on April 7 it was recommended that dimension A should be changed from 23½ in. to 22½ in. for sizes Nos. 3, 4 and 5 to meet this criticism of the standard. Dimension A for sizes Nos. 1 and 2 was not revised as the dimensions for these sizes provide sufficient clearance.

## STARTING-CRANK STANDARD PROPOSED

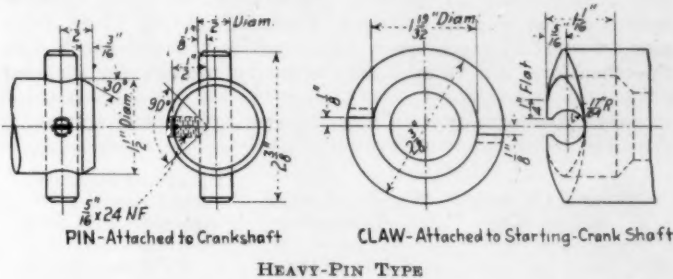
### Engine Division Recommends a Four-Jaw, a Light and a Heavy-Pin Type

In 1921 the Engine Division was requested by a manufacturer of starting-cranks to establish a standard that would make it possible for the industry to eliminate a large number of the types and sizes of starting-crank used. Appreciating the need of such standardization, a Subdivision was appointed to make a study of the situation, and a preliminary recommendation was submitted in 1922 for consideration. Changes were made as a result of Division discussion and also as a result of circularizing the report among automobile builders. At the last meeting of the Engine Division, a final report was submitted by L. P. Kalb, of



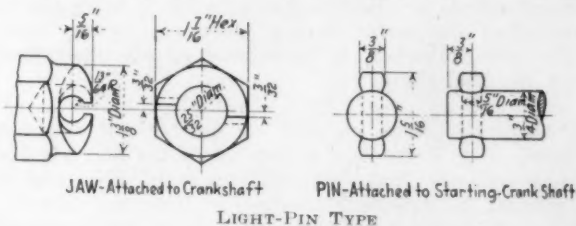
### CUTTER FOR FOUR-JAW TYPE

the Continental Motors Corporation, based on the result of a questionnaire sent to engine manufacturers and passenger-car and motor-truck builders making their own engines.



### HEAVY-PIN TYPE

The report as submitted to the industry for comment included both a light and a heavy-duty three and four-jaw type and a light and a heavy-pin type of starting-crank. Although it was recognized that these types of starting-crank are necessary to meet the entire range of requirements, the Division agreed with Mr. Kalb that the light and heavy-pin types and the heavy four-jaw type of starting-crank were all that were necessary for adoption as recommended practice to meet the requirements of the majority of car builders.



### LIGHT-PIN TYPE

The Division, therefore, recommended the adoption of these types, given in the accompanying drawing, as S.A.E. Recommended Practice.

## ONLY THREE DRAIN-PLUG SIZES NEEDED

Engine Division Recommends  $\frac{7}{8}$ -In.—18, and  $\frac{3}{8}$  and  $\frac{1}{2}$ -In. Taper Pipe Threads

The Engine Division has proposed the adoption as S.A.E. Recommended Practice of three sizes of crankcase drain-plugs to facilitate draining the oil. With the present variety of sizes of drain-plug used it is necessary for service-stations to carry a large variety of wrenches, over 23 sizes of drain-plug being used on current automobile models. In the majority of cases the size of drain-plug is not sufficient to permit rapid draining of the oil.

The Engine Division recommendation was adopted at the April meeting, a Subdivision report having been submitted by L. B. Sperry, of the International Harvester Co., who had been appointed a committee of one to review the situation. The result of a survey that Mr. Sperry had made indicated a decided difference of opinion as to the desirability of establishing standard sizes of drain-plug, and he did not as a result recommend the adoption of a recommended practice. The subject was discussed at length at the Engine Division meeting, and it was finally decided that a recommended practice for crankcase drain-plugs would encourage manufacturers to use drain-plugs of ample size even though the industry as a whole did not adopt the exact

sizes specified. The Division, therefore, proposed for adoption as recommended practice that crankcase drain-plugs should be threaded with either a  $\frac{3}{8}$  in.-18 straight thread or a  $\frac{3}{8}$  or  $\frac{1}{2}$ -in. taper pipe thread. The  $\frac{3}{8}$  in.-18 thread is desirable for use in crankcases where a boss is not welded to the crankcase pan, and it has the advantage of being the same as the spark-plug thread.

### LIGHTING-PLANT RATINGS CHANGED

#### Division Recommends a Speed of 860 R.P.M. for 2-Kw. and Larger Plants

At a joint meeting of a committee appointed by the Electric Power Club on Isolated Farm-Lighting-Plant Generators and the S.A.E. Isolated Electric-Lighting-Plant Division, several changes were suggested in the present S.A.E. Specifications for voltage and capacity ratings for isolated

TABLE 1—VOLTAGE AND ENGINE AND GENERATOR SPEEDS

Nominal Generator Rating, Kw.	Nominal Service Voltage <sup>1</sup>	Full-Load Engine and Generator Speed (R.P.M.)
$\frac{1}{2}$	32, 64 or 112	1150 or 1720
$\frac{3}{4}$	32, 64 or 112	1150 or 1720
1	32, 64 or 112	1150 or 1720
$1\frac{1}{2}$	32, 64 or 112	1150 or 1720
2	32, 64 or 112	860, 1150 or 1720
3	32, 64 or 112	860, 1150 or 1720
5	64 or 112	860, 1150 or 1720

<sup>1</sup> See Table 2 for number of cells to be used for each voltage.

The speeds specified in the above table are standard in the electrical industries and are intended as a guide toward standard practice for isolated lighting-plants. The design and performance of some plants may make it desirable, however, to operate at speeds other than those specified above.

electric-lighting plants printed on p. D92 of the S.A.E. HANDBOOK. The Committee appointed by the Electric Power Club recommended that full-load speeds of 1150 and 1720 r.p.m. should be specified instead of "no-load" speeds of 1200 and 1800 r.p.m., and that for lighting plants rated at 2 kw. and larger a speed of 860 r.p.m. be specified. The

TABLE 2—NUMBER OF CELLS REQUIRED FOR EACH VOLTAGE

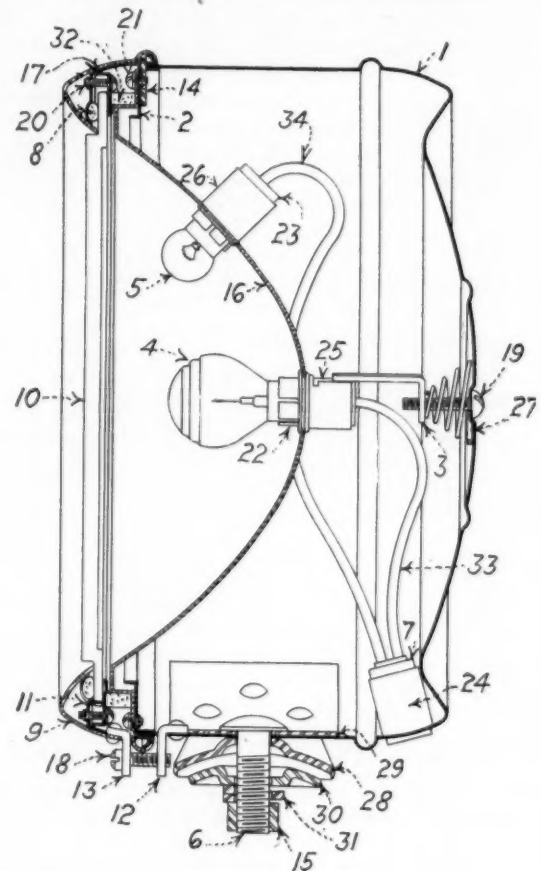
Nominal Service Voltage	NUMBER OF CELLS	
	Nickel-Alkali Batteries	Lead-Acid Batteries
32	26	16
64	52	32
112	92	56

Committee also recommended that the nominal voltage specified be changed to "service voltage," 110 volts being increased to 112 volts and a service voltage of 64 volts included for all sizes of lighting plants. The present specifications revised and extended as proposed are given in the accompanying tables.

### HEAD-LAMP NOMENCLATURE REVISED

The Lighting Division has recommended that the present S.A.E. Standard for Head-Lamp Nomenclature, printed on p. B9 of the S.A.E. HANDBOOK, should be revised to agree with the nomenclature given in the accompanying report inasmuch as head-lamp construction has changed to some extent since the present nomenclature was adopted in 1917. In submitting this recommendation the Lighting Division recommends that the present S.A.E. Standard for Lighting Nomenclature, p. B11, be cancelled as it is not believed necessary to include these terms in the S.A.E. Nomenclature.

### PROPOSED HEAD-LAMP NOMENCLATURE



#### Head-lamp

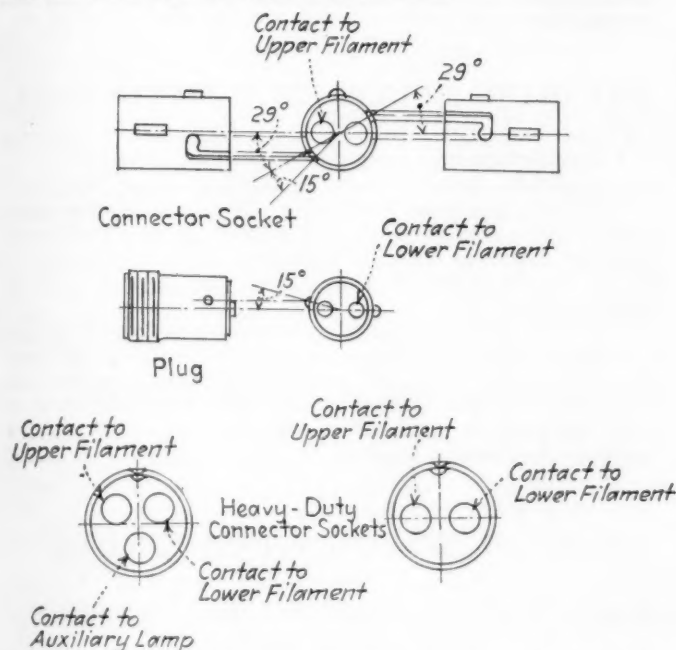
- (1) Head-lamp housing
- (2) Head-lamp housing flange
- (3) Head-lamp focusing bar
- (4) Head-lamp electric incandescent lamp
- (5) Head-lamp auxiliary electric incandescent lamp
- (6) Head-lamp mounting bolt
- (7) Head-lamp connector socket
- (8) Head-lamp lens gasket
- (9) Head-lamp door
- (10) Head-lamp lens
- (11) Head-lamp door stiffener
- (12) Head-lamp housing lug
- (13) Head-lamp door lug
- (14) Head-lamp door retainer
- (15) Head-lamp mounting bolt nut
- (16) Head-lamp reflector
- (17) Head-lamp lens retainer
- (18) Head-lamp door fastening screw
- (19) Head-lamp focusing screw
- (20) Head-lamp lens retainer screw
- (21) Head-lamp reflector mounting screw
- (22) Head-lamp electric incandescent lamp socket
- (23) Head-lamp auxiliary electric incandescent lamp socket
- (24) Head-lamp connector socket retainer
- (25) Head-lamp focusing socket guide
- (26) Head-lamp auxiliary electric incandescent lamp socket retainer
- (27) Head-lamp focusing spring
- (28) Head-lamp housing mounting
- (29) Head-lamp housing mounting stiffener
- (30) Head-lamp mounting washer
- (31) Head-lamp mounting lock-washer
- (32) Head-lamp reflector gasket
- (33) Head-lamp socket-connector cable
- (34) Head-lamp auxiliary electric incandescent lamp socket-connector cable

## OFFSET-SLOT CONNECTOR PROPOSED

### Construction Intended To Prevent Wrong Connections with Two-Filament Lamps

Following the adoption of two-filament lamps by several of the car builders, trouble has been experienced as a result of the plug and socket of the lamp being connected so that the lower head-lamp filament is lighted when it is desired to light the upper filament and vice-versa.

So that the plugs and sockets can be put together in the correct way only, the connectors now used by the Studebaker Corporation of America, the Hupp Motor Car Corporation and the Buick Motor Co. have dimensions agreeing with the present S.A.E. Standard double-contact connector, p. B5a of the S.A.E. HANDBOOK, with the exception that one pin is offset 15 deg. from the vertical center-line. This type of connector can be used for head-lamps using two-filament lamps, one contact being used for the auxiliary filament and the other for the main filament, or for combination tail and stop-lamps, one contact being used for the tail-lamp filament and the other for the stop-lamp filament.



PROPOSED S.A.E. STANDARD CONNECTOR FOR TWO-FILAMENT LAMPS

At the meeting of the Subdivision on Bases, Sockets and Connectors, held in Detroit on Jan. 27, it was suggested by C. E. Godley, of the Edmunds & Jones Corporation, that an alternate S.A.E. Standard for two-filament lamp connectors should be adopted to avoid different designs of this type of connector being developed. As it was felt that such standardization should follow current practice, the 15-deg. offset was approved by the Subdivision. The Subdivision recommendation, given in the accompanying drawing, was subsequently approved by the Lighting Division and will be submitted for action at the Summer Meeting.

## HEAD-LAMP CONSTRUCTION OUTLINED

### Lighting Division Recommends Desirable Head-Lamp Construction Details

During the last few years motor-vehicle administrators have, in an effort to obtain more reliable head-lamp equipment, specified details of head-lamp construction that were considered desirable. Foreseeing that the adoption of conflicting construction limitations in head-lamp design by various States would work to the disadvantage of the car

builders in that head-lamp equipment acceptable in one State might not be acceptable in another, the Lighting Division has outlined details of head-lamp construction that are considered desirable from the viewpoint of both the car builder and the motor-vehicle administrator. In developing these specifications the limitations of the lamp manufacturer were considered in order not to work undue hardship on any one lamp manufacturer.

The specifications were developed by a Subdivision under the chairmanship of R. N. Falge, the complete personnel being:

R. N. Falge, <i>Chairman</i>	National Lamp Works
A. W. Devine	Commonwealth of Massachusetts
C. A. Michel	Guide Motor Lamp Mfg. Co.
H. H. Oetjen	Edmunds & Jones Corporation
B. M. Smarr	General Motors Corporation
T. E. Wagar	Studebaker Corporation of America

Meetings of the Subdivision were held on Jan. 28 in Detroit and on April 5 in Cleveland. The Subdivision report was approved practically as submitted by the Lighting Division on April 6 in Cleveland. It was impossible for the Subdivision to submit a final report owing to the fact that the test for head-lamp deflection and the reflective factor for reflectors after 1 year's service has not been definitely determined. A supplementary report covering these points will be submitted by the Subdivision at a later date.

### PROPOSED SPECIFICATIONS FOR HEAD-LAMP CONSTRUCTION

- (1) The fenders should not be tied together through the head-lamps
- (2) The construction should be such as to permit the installation of the lens in the proper position only
- (3) The construction should be such that the lens is securely held while the door is being removed
- (4) The construction should be such as to protect the lens against excessive local strains
- (5) Suitable provision should be made for the drainage of moisture condensing in the head-lamps
- (6) The design relation between the socket and the reflector should be correct when the door is installed
- (7) The finished reflector should withstand corrosion under normal service conditions
- (8) The reflector should be of such design and weight as to show no beam distortion when assembled in the head-lamp
- (9) The lamp housing should be rigidly constructed by using metal of suitable weight and/or by stiffening the opening
- (10) The head-lamp, with the mounting firmly attached to a fixed support and with a steady pressure of 75 lb., applied for 5 min. to the upper edge of the door parallel with the head-lamp axis, should not cause a permanent distortion, as measured by the deflection of the beam, of more than . . . deg.
- (11) The head-lamp door should be constructed so that it may be easily attached to or removed from the housing
- (12) The reflector should be protected from dust and moisture by a suitable gasket
- (13) The reflection factor of the reflector should not fall below . . . per cent after 1 year's service under normal operating-conditions
- (14) The section of the beam normal to the axis at 100 ft. from a parabolical reflector with a filament 0.10 in. long by 0.10 in. wide should all be within a circle having a diameter of 105 in.

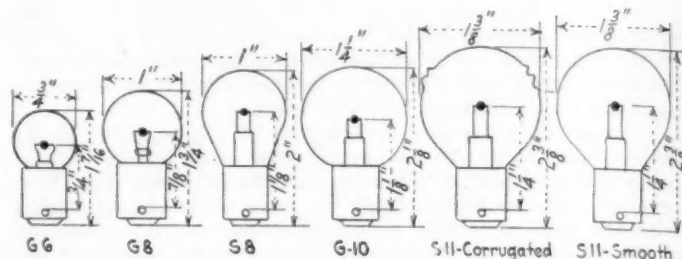
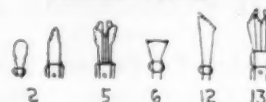
- (15) The construction should be such as to permit the installation of the reflector in the proper position only
- (16) The focusing mechanism should be constructed of such materials that no two ferrous metals work upon each other
- (17) The head-lamp socket should be constructed so as to hold the base of the electric incandescent lamp firmly and accurately
- (18) Means should be provided for holding the head-lamp socket firmly and accurately in its proper position
- (19) Both the head-lamp socket and its guide should be made of non-ferrous metals
- (20) Solid current-path type sockets and connectors should be used
- (21) The head-lamp mounting should be in the vertical center plane of the head-lamp
- (22) The focusing screw should be accessible from the outside when the head-lamp is completely assembled and mounted
- (23) The head-lamp should be designed so that not more than one focusing adjustment is necessary

### LAMP SPECIFICATIONS EXTENDED

#### Filament-Shape Covered in Revised Report Submitted by Lighting Division

The present S.A.E. Specifications for Electric Incandescent Lamps, p. B4 of the S.A.E. HANDBOOK, have been extended by the Lighting Division to provide sufficient information for automobile designers to determine the type and size of standard lamps suitable for their requirements. The

Filament Forms



PROPOSED DIMENSIONS FOR ELECTRIC INCANDESCENT LAMPS  
Over-all dimensions are maximum. Light-center length and axial-alignment tolerances are  $\pm 3/64$  in.  
C indicates a coiled wire filament.  
S indicates a straight wire filament.

specifications extended as proposed are given in the accompanying table.

### STANDARD MOLYBDENUM STEELS USED

At the June, 1925, Meeting of the Standards Committee four molybdenum-steel compositions were approved for adoption as S.A.E. Recommended Practice, it being understood that the Iron and Steel Division would reconsider the specifications in 1 year to determine whether it was possible to recognize them as S.A.E. Standard, such recognition to depend on the extent that the steels had been adopted in actual practice.

As it is understood that these compositions are used now in actual practice in preference to other molybdenum steel compositions, the Iron and Steel Division has approved the recognition of these steels as S.A.E. Standard, and a recommendation to this effect will be submitted at the Standards Committee Meeting in June.

PROPOSED DIMENSIONS FOR ELECTRIC INCANDESCENT LAMPS

Rated Candle- power	Voltage		Am- perage	Single or Double- Contact	Bulb		Maximum Over- All Length	Light- Center Length	Fila- ment Con- struction
	Circuit	Design			No.	Diam- eter			
2	3-4	3.45	0.84	Single	G6	3/4	1 1/8	3/4	S2
2	3-4	3.45	0.84	Double	G6	3/4	1 1/8	3/4	S2
3	0-8	6.85	0.55	Single	G6	3/4	1 1/8	3/4	C2
3	0-8	6.85	0.55	Double	G6	3/4	1 1/8	3/4	C2
3	12-16	14.20	0.30	Single	G6	3/4	1 1/8	3/4	C2
3	12-16	14.20	0.30	Double	G6	3/4	1 1/8	3/4	C2
3	18-24	22.00	0.18	Single	G6	3/4	1 1/8	3/4	C2
3	18-24	22.00	0.18	Double	G6	3/4	1 1/8	3/4	C2
3	18-24	22.00	0.18	Double	G6	3/4	1 1/8	3/4	C2
6	0-8	6.90	0.91	Single	G8	1	1 3/4	3/4	C2
6	0-8	6.90	0.91	Double	G8	1	1 3/4	3/4	C2
6	12-16	14.20	0.55	Single	G8	1	1 3/4	3/4	C2
6	12-16	14.20	0.55	Double	G8	1	1 3/4	3/4	C2
6	40-44	44.00	0.17	Double	G10	1 1/4	2 1/4	1 1/4	C5
15	0-8	6.75	1.78	Single	S8	1	1 3/4	3/4	C2
15	0-8	6.75	1.78	Double	S8	1	1 3/4	3/4	C2
21	0-8	6.50	2.68	Double	S11	...	2 3/4	1 1/4	C2
21	0-8	6.50	2.68	Double	S11	...	2 3/4	1 1/4	C2
21	0-8	6.50	2.52	Single	S11	1 3/4	2 3/4	1 1/4	C2
21	0-8	6.50	2.52	Double	S11	1 3/4	2 3/4	1 1/4	C2
21	0-8	6.50	2.52	Double	S11	1 3/4	2 3/4	1 1/4	C2
21	12-16	14.15	1.19	Single	S11	1 3/4	2 3/4	1 1/4	C2
21	12-16	14.15	1.33	Double	S11*	1 3/4	2 3/4	1 1/4	C2
21	40-44	44.00	0.48	Double	S11	1 3/4	2 3/4	1 1/4	C13
21	0-8	6.50	2.68	Double	S11	1 3/4	2 3/4	1 1/4	C2
21	0-8	6.50	0.64	Double	S11	1 3/4	2 3/4	1 1/4	C12
21	9	6.50	2.52	Double	S11	1 3/4	2 3/4	1 1/4	C2
27	9	9.00	2.14	Double	S11	1 3/4	2 3/4	1 1/4	C2
27	18-24	22.00	0.96	Double	S11	1 3/4	2 3/4	1 1/4	C2
32	0-8	6.00	3.95	Single	S11	1 3/4	2 3/4	1 1/4	C2
32	0-8	6.00	3.95	Double	S11	1 3/4	2 3/4	1 1/4	C2
32	12-16	13.75	1.70	Single	S11	1 3/4	2 3/4	1 1/4	C2
32	12-16	13.75	1.70	Double	S11	1 3/4	2 3/4	1 1/4	C2

\* Smooth bulb.

### S.A.E. OIL SPECIFICATIONS REVISED

#### American Society for Testing Materials, Committee D2, To Determine Numbers

In the April issue of THE JOURNAL, on p. 345, H. C. Mougey, chairman of the Lubricants Division, outlined the history and present status of the work his Division has carried on in the standardization of crankcase lubricating oils. As stated in Mr. Mougey's article, the real need for S.A.E. Lubricating Oil Specifications is to provide a system of nomenclature that will enable the automobile engineers to recommend oils suitable for use in engines they design and build and will enable oil companies to make the oils they sell such that the public can buy oils of the grade recommended by the automobile builders. At a joint meeting of a Sub-Committee of Committee D2 of the American Society for Testing Materials and the Lubricants Division on April 2 in Baltimore, the viscosity ranges given in the accompanying table were determined upon. The numbers used for designating the grades were not decided upon at the joint meeting as a difference of opinion existed as to whether numbers indicative of the viscosity should be used or arbitrary numbers such as are given in the accompanying table. It was felt that the actual number used was of no importance to the car builders, this being a matter for the oil refiners to determine based on their experience in marketing lubricating oil. The matter was, therefore, referred to Committee D2 which held a meeting on the following day. At that meeting no definite action was taken, it being thought advisable to determine the consensus of opinion of all members

## STANDARDS COMMITTEE DIVISION REPORTS

427

of Committee D2 and of the members of the American Petroleum Institute before taking final action. It is expected that a definite recommendation will be determined upon before the June meeting of the Standards Committee, and if so, the Lubricants Division will submit a supplementary report covering the grade numbers. This report, if adopted by the Society, will supersede the present S.A.E. Recommended Practice for Crankcase Lubricating Oils printed on p. D151 of the S.A.E. HANDBOOK.

## PROPOSED CRANKCASE LUBRICATING-OIL SPECIFICATIONS

Tentative Number <sup>1</sup>	Viscosity Range <sup>2</sup>	
	At 130 Deg. Fahr.	At 210 Deg. Fahr.
1	90-115	.....
2	120-150	.....
3	185-220	.....
4	255-	-70
5	.....	75-95
6	.....	105-120

<sup>1</sup> Grade numbers adopted by Committee D-2 are to replace the tentative numbers used in the specifications as adopted by the Society.

<sup>2</sup> Oils with viscosities falling between the ranges specified shall be classified in the next lower grades.

With the viscosity ranges proposed certain oils now being marketed will fall between the limits proposed. To avoid any confusion resulting from this situation the Division has specified that oils falling between the viscosity ranges proposed shall be classified in the next lower grades.

The revised report will be submitted by the Lubricants Division for action at the June meeting of the Standards Committee. Members interested in discussing this report should refer to the review of these specifications printed on p. 345 of the April issue of THE JOURNAL.

## HUB ODOMETERS STANDARD CANCELLED

The Motor Truck Division has recommended that the present S.A.E. Standard for Hub Odometers for Motor Trucks, printed on p. F2 of the S.A.E. HANDBOOK, should be cancelled as it no longer represents standard practice, a more convenient and cheaper assembly being possible by mounting the odometer mechanism directly in the hub-cap or an adapter. The S.A.E. Standard, adopted in 1919, was based on the design used in the Class B military truck. The mounting is larger than is desirable in order to accommodate all types of odometer.

## BRAKE-LINING STANDARD EXTENDED

## Thirty-Seven Sizes Included in Proposed Revision of Present Standard

In December, 1924, a conference was held at the City of Washington by the Division of Simplified Practice on the simplification of brake-lining. The Society was asked at this conference to revise the present S.A.E. Standard for Brake-Lining, p. C53 of the S.A.E. HANDBOOK, to meet the requirements for new automotive equipment so that the revised standard might serve as a basis for a Simplified Practice.

Using the present S.A.E. Standard as a basis, a recommendation was developed by a Subdivision of the Parts and Fittings Division, of which Dr. F. C. Stanley, of the Raybestos Co., was chairman, covering 37 sizes of brake-lining. The present standard, revised to include the proposed sizes, is given in the accompanying table.

The revised table, which was approved at the April Meeting of the Parts and Fittings Division, will be found to include several 5/16-in. sizes that are not used to any great extent, but it was considered desirable that the recommendation should cover a certain range of widths in the 5/16-in. sizes to meet the needs of motorcoach design.

The report, when approved by the Society, will be trans-

## PROPOSED BRAKE-LINING DIMENSIONS

Width, In. = 1/16	Thickness, In.			
	5/32 +0.000 -0.020	3/16 +0.000 -0.020	1/4 +0.000 -0.031	5/16 +0.000 -0.031
1 1/8	1 1/8	1 1/8	...	...
1 1/4	1 1/4	1 1/4	...	...
1 1/2	1 1/2	1 1/2	...	...
1 5/8	1 5/8	1 5/8	...	...
1 3/4	1 3/4	1 3/4	1 3/4	...
1 7/8	1 7/8	...	...	...
2	2	2	2	...
2 1/4	...	2 1/4	2 1/4	...
2 1/2	2 1/2	2 1/2	2 1/2	...
2 3/4	...	2 3/4	2 3/4	...
3	...	3	3	...
3 1/4	...	3 1/4	3 1/4	...
3 1/2	...	3 1/2	3 1/2	...
3 3/4	...	...	3 3/4	...
4	...	...	4	4
4 1/2	...	...	4 1/2	4 1/2
5	...	...	5	5
6	...	...	6	6

mitted to the Division of Simplified Practice for consideration at a general conference for adoption as a Simplified Practice. It is hoped that this standard will be generally followed by car builders in future production and that in servicing existing equipment the proposed sizes will be adhered to even though they may not be the exact sizes originally intended.

## RADIATOR NOMENCLATURE REVISED

## Core Definitions, Referred Back to Radiator Division in 1923, Rewritten

At the June, 1923, Meeting of the Standards Committee definitions covering various types of radiator core were submitted by the Radiator Division as an extension of the present S.A.E. Radiator Nomenclature, but owing to the objections raised at that meeting, the definitions were referred back to the Radiator Division for reconsideration. As the work before the Radiator Division did not warrant a meeting during 1924 and 1925, it was not possible to reconsider these definitions until the January, 1926, Meeting of the 1925 Radiator Division. At this meeting the objections raised at the 1923 Standards Committee Meeting were carefully studied, and revisions made such that it is believed that the revised definitions will now meet with general approval. These revised definitions follow:

**Individual Fin and Tube Core.**—An assembly of fluid tubes of any cross-sectional form to each of which are attached gills or fins of circular, square or other shape, each tube and its fin or fins forming a separate unit.

**Continuous Fin and Tube Core.**—An assembly of fluid tubes of any cross-sectional form, the tubes being joined together by radiating fins or plates common to all tubes or groups of tubes.

**Ribbon Cellular Core.**—A number of fluid passages made by joining metal ribbons at the edges and grouped to form a cellular structure. Parts of the cellular structure may be of formed or flat ribbon which is not a part of the fluid passage.

**Air Tube Cellular Core.**—An assembly of air tubes nested in such a way as to form fluid passages between the tubes, the passages being sealed at the ends of the tubes. In this type the fluid may flow transversely as well as vertically around the tubes.

The present S.A.E. Standard Nomenclature covering radiators of the shell and cast type, now printed on p. K5 of the S.A.E. HANDBOOK, was also revised at the January meeting. As the term "core" is very often used incorrectly

when it is desired to designate the "complete core and tank assembly," a separate classification was adopted for the core and tank assembly. Other revisions deemed advisable were made. Although it had been suggested that nomenclature be drawn up to cover the evaporative method of cooling, this was considered inadvisable until this method had been adopted in commercial use.

#### SHELL TYPE

##### Radiator Core and Tank Assembly

Radiator core  
Radiator core header sheets  
Radiator upper tank  
Radiator filler-neck  
Radiator filler-neck sleeve  
Radiator filler-cap  
Radiator filler-cap gasket  
Radiator tie-rod fitting  
Radiator baffle  
Radiator inlet fitting  
Radiator lower tank  
Radiator outlet fitting  
Radiator drain flange  
Radiator drain-cock  
Radiator anchor stud or bolt  
Radiator anchor stud or bolt plate  
Radiator overflow tube  
Radiator side bolting-member  
Radiator shell anchorage clips

##### Radiator Shell

Radiator supports  
Radiator anchor studs or bolts  
Radiator support reinforcement  
Radiator hinge-rod fitting  
Radiator brace-rod fitting  
Radiator hood-ledge liner strip  
Radiator starting-crank hole cover

#### CAST TYPE

##### Radiator Core Assembly

Radiator core  
Radiator core upper header  
Radiator core lower header  
Radiator core overflow jacket tube

##### Radiator Upper Tank

Radiator filler-cap  
Radiator filler-cap gasket  
Radiator filler-cap hinge-pin  
Radiator filler-cap fastener  
Radiator tie-rod fitting  
Radiator hinge-rod fitting  
Radiator inlet fitting  
Radiator inlet gasket  
Radiator inlet studs or cap-screws

##### Radiator Lower Tank

Radiator anchor studs or bolts  
Radiator outlet fitting  
Radiator outlet gasket  
Radiator outlet studs or cap-screws  
Radiator drain-cock or plug  
Radiator clamping strips  
Radiator clamping bolts or studs  
Radiator overflow tube  
Radiator sides  
Radiator header gasket  
Radiator hood-ledge liner strip

#### RADIATOR TIE-ROD DESIGN CANCELLED

The Radiator Division has recommended that the present S.A.E. Standard for Radiators, p. A26 of the S.A.E. HANDBOOK, be revised by deleting tie-rod fitting design for motor-truck radiators given on p. A28, which is in accordance

with the design of the tie-rod fitting that was used on Class B Military Trucks and including the following statement covering the design of tie-rod fittings.

Tie-rod fittings shall be cast integral with the upper tank and shall be designed to take S.A.E. Standard rod-end fittings. The use of a tapped hole for rods with a threaded-end is permissible.

#### WATER-PIPE FLANGE REVISED

The Radiator Division has also proposed that the present S.A.E. Recommended Practice for Water-Pipe Flanges, p. A28 of the S.A.E. HANDBOOK, be revised to specify the length of fitting for lap of hose as the minimum instead of as a nominal dimension.

#### EXTRA-FINE THREAD FITS RECOMMENDED

##### Report by Earle Buckingham and Arthur Boor Completes Work on S.A.E. Threads

The Screw-Threads Division report submitted in February, 1924, and printed on p. C1 of the S.A.E. HANDBOOK, covers the tolerances for the S.A.E. Coarse and Fine Thread Series, formerly known as the U. S. Standard and the S.A.E. Standard Thread Series. At the June, 1925, Meeting of the Standards Committee a report was submitted by the Screw-Threads Division covering the fits and tolerances for the Extra-Fine Thread Series, formerly known as the S.A.E. Fine Thread Series. This report was based on the work of Earle Buckingham, then of the Niles-Bement-Pond Co.

At the Standards Committee Meeting this report was withdrawn by the Screw-Threads Division because, at a meeting of members of the Parts and Fittings and the Screw-Threads Divisions preceding the Standards Committee Meeting, it was decided that the fits recommended were not sufficiently close, threaded parts made in accordance with the report having an appreciable shake. The report was subsequently revised and extended by a Subdivision consisting of Mr. Buckingham and Arthur Boor of the Willys-Overland Co., fits and tolerances for the fine-thread series for diameters over 1½ in. being included. The revised report covering both the extra-fine and the fine thread series is given in Tables 14 to 27 inclusive. If adopted by the Society these tables will constitute an extension of the present S.A.E. Standard for Screw-Threads now printed in the S.A.E. HANDBOOK.

TABLE 14—BASIC DIAMETERS AND THREAD DATA FOR THE EXTRA-FINE THREAD SERIES

Sizes	Threads per Inch	Basic Major Diameter	Basic Pitch Diameter	Basic Minor Diameter	Pitch <sup>1</sup>	Basic Depth of Thread
¼	36	0.2500	0.2320	0.2139	0.0277778	0.01804
⅜	32	0.3125	0.2922	0.2719	0.0312500	0.02030
½	32	0.3750	0.3547	0.3344	0.0312500	0.02030
⅝	28	0.4375	0.4143	0.3911	0.0357143	0.02319
¾	28	0.5000	0.4768	0.4536	0.0357143	0.02319
⅞	24	0.5625	0.5354	0.5084	0.0416667	0.02706
1	24	0.6250	0.5979	0.5709	0.0416667	0.02706
1 ⅛	20	0.7500	0.7175	0.6850	0.0500000	0.03248
1 ¼	20	0.8750	0.8425	0.8100	0.0500000	0.03248
1 ½	20	1.0000	0.9675	0.9350	0.0500000	0.03248
1 ⅝	18	1.1250	1.0889	1.0528	0.0555556	0.03608
1 ¾	18	1.2500	1.2139	1.1778	0.0555556	0.03608
2	18	1.5000	1.4639	1.4278	0.0555556	0.03608
2 ⅛	16	1.7500	1.7094	1.6778	0.0625000	0.04060
2 ¼	16	2.0000	1.9594	1.9278	0.0625000	0.04060
2 ½	16	2.2500	2.2094	2.1778	0.0625000	0.04060
2 ¾	16	2.5000	2.4594	2.4278	0.0625000	0.04060
3	16	2.7500	2.7094	2.6778	0.0625000	0.04060
3 ⅛	16	3.0000	2.9594	2.9278	0.0625000	0.04060
3 ¼	16	3.5000	3.4594	3.4278	0.0625000	0.04060
4	16	4.0000	3.9594	3.9278	0.0625000	0.04060

All dimensions in inches.

<sup>1</sup> This column is given to seven decimal places for computation purposes only.

## STANDARDS COMMITTEE DIVISION REPORTS

429

TABLE 15—FREE FIT (CLASS C) FOR SCREWS IN THE EXTRA-FINE THREAD SERIES

Size	Threads per Inch	Major Diameter			Pitch Diameter			Maximum <sup>1</sup> Minor Diameter
		Maximum <sup>1</sup>	Tolerance	Minimum	Maximum	Tolerance <sup>2</sup>	Minimum	
1/4	36	0.2500	0.0050	0.2450	0.2320	0.0027	0.2293	0.2159
1/4	32	0.3125	0.0054	0.3071	0.2922	0.0029	0.2893	0.2742
1/4	32	0.3750	0.0054	0.3696	0.3547	0.0030	0.3517	0.3367
1/4	28	0.4375	0.0062	0.4313	0.4143	0.0032	0.4111	0.3937
1/4	28	0.5000	0.0062	0.4938	0.4768	0.0033	0.4735	0.4562
1/4	24	0.5625	0.0066	0.5559	0.5354	0.0035	0.5319	0.5114
1/4	24	0.6250	0.0066	0.6184	0.5979	0.0036	0.5943	0.5739
1/4	20	0.7500	0.0072	0.7428	0.7175	0.0040	0.7135	0.6887
1/4	20	0.8750	0.0072	0.8678	0.8425	0.0041	0.8384	0.8137
1	20	1.0000	0.0072	0.9928	0.9675	0.0042	0.9633	0.9387
1 1/4	18	1.1250	0.0082	1.1168	1.0889	0.0045	1.0844	1.0568
1 1/4	18	1.2500	0.0082	1.2418	1.2139	0.0046	1.2093	1.1818
1 1/4	18	1.5000	0.0082	1.4918	1.4639	0.0048	1.4591	1.4318
1 1/4	16	1.7500	0.0090	1.7410	1.7094	0.0051	1.7043	1.6733
2	16	2.0000	0.0090	1.9910	1.9594	0.0053	1.9541	1.9233
2 1/4	16	2.2500	0.0090	2.2410	2.2094	0.0055	2.2039	2.1733
2 1/4	16	2.5000	0.0090	2.4910	2.4594	0.0057	2.4537	2.4233
2 1/4	16	2.7500	0.0090	2.7410	2.7094	0.0058	2.7036	2.6733
3	16	3.0000	0.0090	2.9910	2.9594	0.0060	2.9534	2.9233
3 1/2	16	3.5000	0.0090	3.4910	3.4594	0.0062	3.4532	3.4233
4	16	4.0000	0.0090	3.9910	3.9594	0.0065	3.9529	3.9233

All dimensions in inches.

<sup>1</sup> Basic diameter.<sup>2</sup> The tolerances specified for pitch diameter are cumulative and include errors of lead and angle.<sup>3</sup> Dimensions given are figured to the intersection of the worn tool arc with a centerline through crest and root. Minimum flat at root equals  $\frac{1}{4} \times p$ .

TABLE 17—MEDIUM FIT (CLASS D) FOR SCREWS IN THE EXTRA-FINE THREAD SERIES

Size	Threads per Inch	Major Diameter			Pitch Diameter			Maximum <sup>1</sup> Minor Diameter
		Maximum <sup>1</sup>	Tolerance	Minimum	Maximum <sup>1</sup>	Tolerance <sup>2</sup>	Minimum	
1/4	36	0.2500	0.0050	0.2450	0.2320	0.0018	0.2302	0.2159
1/4	32	0.3125	0.0054	0.3071	0.2922	0.0020	0.2902	0.2742
1/4	32	0.3750	0.0054	0.3696	0.3547	0.0021	0.3526	0.3367
1/4	28	0.4375	0.0062	0.4313	0.4143	0.0023	0.4120	0.3937
1/4	28	0.5000	0.0062	0.4938	0.4768	0.0024	0.4744	0.4562
1/4	24	0.5625	0.0066	0.5559	0.5354	0.0025	0.5329	0.5114
1/4	24	0.6250	0.0066	0.6184	0.5979	0.0026	0.5953	0.5739
1/4	20	0.7500	0.0072	0.7428	0.7175	0.0029	0.7149	0.6887
1/4	20	0.8750	0.0072	0.8678	0.8425	0.0030	0.8395	0.8137
1	20	1.0000	0.0072	0.9928	0.9675	0.0031	0.9644	0.9387
1 1/4	18	1.1250	0.0082	1.1168	1.0889	0.0033	1.0856	1.0568
1 1/4	18	1.2500	0.0082	1.2418	1.2139	0.0034	1.2105	1.1818
1 1/4	18	1.5000	0.0082	1.4918	1.4639	0.0036	1.4603	1.4318
1 1/4	16	1.7500	0.0090	1.7410	1.7094	0.0039	1.7055	1.6733
2	16	2.0000	0.0090	1.9910	1.9594	0.0041	1.9553	1.9233
2 1/4	16	2.2500	0.0090	2.2410	2.2094	0.0042	2.2052	2.1733
2 1/4	16	2.5000	0.0090	2.4910	2.4594	0.0044	2.4550	2.4233
2 1/4	16	2.7500	0.0090	2.7410	2.7094	0.0046	2.7048	2.6733
3	16	3.0000	0.0090	2.9910	2.9594	0.0047	2.9547	2.9233
3 1/2	16	3.5000	0.0090	3.4910	3.4594	0.0050	3.4544	3.4233
4	16	4.0000	0.0090	3.9910	3.9594	0.0053	3.9541	3.9233

All dimensions in inches.

<sup>1</sup> Basic diameter.<sup>2</sup> The tolerances specified for pitch diameter are cumulative and include errors of lead and angle.<sup>3</sup> Dimensions given are figured to the intersection of the worn tool arc with a centerline through crest and root. Minimum flat at root equals  $\frac{1}{4} \times p$ .

TABLE 16—FREE FIT (CLASS C) FOR NUTS IN THE EXTRA FINE-THREAD SERIES

Size	Threads per Inch	Minimum Major Diameter <sup>1</sup>	Pitch Diameter			Minor Diameter		
			Minimum <sup>2</sup>	Tolerance <sup>3</sup>	Maximum	Minimum	Tolerance	Maximum
1/4	36	0.2500	0.2320	0.0027	0.2347	0.2199	0.0030	0.2229
1/4	32	0.3125	0.2922	0.0029	0.2951	0.2787	0.0034	0.2821
1/4	32	0.3750	0.3547	0.0030	0.3577	0.3412	0.0034	0.3446
1/4	28	0.4375	0.4143	0.0032	0.4175	0.3988	0.0039	0.4027
1/4	28	0.5000	0.4768	0.0033	0.4801	0.4613	0.0039	0.4652
1/4	24	0.5625	0.5354	0.0035	0.5389	0.5174	0.0045	0.5219
1/4	24	0.6250	0.5979	0.0036	0.6015	0.5799	0.0045	0.5844
1/4	20	0.7500	0.7175	0.0040	0.7215	0.6959	0.0054	0.7013
1/4	20	0.8750	0.8425	0.0041	0.8466	0.8209	0.0054	0.8263
1	20	1.0000	0.9675	0.0042	0.9717	0.9459	0.0054	0.9513
1 1/4	18	1.1250	1.0889	0.0045	1.0934	1.0649	0.0060	1.0709
1 1/4	18	1.2500	1.2139	0.0046	1.2185	1.1899	0.0060	1.1959
1 1/4	18	1.5000	1.4639	0.0048	1.4687	1.4399	0.0060	1.4459
1 1/4	16	1.7500	1.7094	0.0051	1.7145	1.6823	0.0068	1.6891
2	16	2.0000	1.9594	0.0053	1.9647	1.9323	0.0068	1.9391
2 1/4	16	2.2500	2.2094	0.0055	2.2149	2.1823	0.0068	2.1891
2 1/4	16	2.5000	2.4594	0.0057	2.4651	2.4323	0.0068	2.4391
2 1/4	16	2.7500	2.7094	0.0058	2.7152	2.6823	0.0068	2.6891
3	16	3.0000	2.9594	0.0060	2.9654	2.9323	0.0068	2.9391
3 1/2	16	3.5000	3.4594	0.0062	3.4656	3.4323	0.0068	3.4391
4	16	4.0000	3.9594	0.0065	3.9659	3.9323	0.0068	3.9391

All dimensions in inches.

<sup>1</sup> Basic diameter. Dimensions given are allowable only with tap having theoretically sharp corners. Threaded hole must not reject correct basic "Go" gage by interference with rounded roots due to worn tap. Minimum flat at root equals  $\frac{1}{24} \times p$ .<sup>2</sup> Basic diameter.<sup>3</sup> The tolerances specified for pitch diameter are cumulative and include errors of lead and angle.

TABLE 18—MEDIUM FIT (CLASS D) FOR NUTS IN THE EXTRA FINE-THREAD SERIES

Size	Threads per Inch	Minimum Major Diameter <sup>1</sup>	Pitch Diameter			Minor Diameter		
			Minimum <sup>2</sup>	Tolerance <sup>3</sup>	Maximum	Minimum	Tolerance	Maximum
1/4	36	0.2500	0.2320	0.0018	0.2338	0.2199	0.0030	0.2229
1/4	32	0.3125	0.2922	0.0020	0.2942	0.2787	0.0034	0.2821
1/4	32	0.3750	0.3547	0.0021	0.3568	0.3412	0.0034	0.3446
1/4	28	0.4375	0.4143	0.0023	0.4166	0.3988	0.0039	0.4027
1/4	28	0.5000	0.4768	0.0024	0.4792	0.4613	0.0039	0.4652
1/4	24	0.5625	0.5354	0.0025	0.5379	0.5174	0.0045	0.5219
1/4	24	0.6250	0.5979	0.0026	0.6005	0.5799	0.0045	0.5844
1/4	20	0.7500	0.7175	0.0029	0.7204	0.6959	0.0054	0.7013
1/4	20	0.8750	0.8425	0.0030	0.8455	0.8209	0.0054	0.8263
1	20	1.0000	0.9675	0.0031	0.9706	0.9459	0.0054	0.9513
1 1/4	18	1.1250	1.0889	0.0033	1.0922	1.0649	0.0060	1.0709
1 1/4	18	1.2500	1.2139	0.0034	1.2173	1.1899	0.0060	1.1959
1 1/4	18	1.5000	1.4639	0.0036	1.4675	1.4399	0.0060	1.4459
1 1/4	16	1.7500	1.7094	0.0039	1.7133	1.6823	0.0068	1.6891
2	16	2.0000	1.9594	0.0041	1.9635	1.9323	0.0068	1.9391
2 1/4	16	2.2500	2.2094	0.0042	2.2136	2.1823	0.0068	2.1891
2 1/4	16	2.5000	2.4594	0.0044	2.4638	2.4323	0.0068	2.4391
2 1/4	16	2.7500	2.7094	0.0046	2.7140	2.6823	0.0068	2.6891
3	16	3.0000	2.9594	0.0047	2.9641	2.9323	0.0068	2.9391
3 1/2	16	3.5000	3.4594	0.0050	3.4644	3.4323	0.0068	3.4391
4	16	4.0000	3.9594	0.0053	3.9647	3.9323	0.0068	3.9391

All dimensions in inches.

<sup>1</sup> Basic diameter. Dimensions given are allowable only with tap having theoretically sharp corners. Threaded hole must not reject correct basic "Go" gage by interference with rounded roots due to worn tap. Minimum flat at root equals  $\frac{1}{24} \times p$ .<sup>2</sup> Basic diameter.<sup>3</sup> The tolerances specified for pitch diameter are cumulative and include errors of lead and angle.

TABLE 19—BASIC DIAMETER AND THREAD DATA FOR FINE-THREAD SERIES OVER 1½-IN. DIAMETER

Size	Threads per Inch	Major Diameter	Pitch Diameter	Minor Diameter	Pitch <sup>1</sup>	Basic Depth of Thread
1¼	12	1.750	1.6959	1.6417	0.0833333	0.05413
2	12	2.000	1.9459	1.8917	0.0833333	0.05413
2¼	12	2.250	2.1959	2.1417	0.0833333	0.05413
2½	12	2.500	2.4459	2.3917	0.0833333	0.05413
2¾	12	2.750	2.6959	2.6417	0.0833333	0.05413
3	10	3.000	2.9350	2.8701	0.1000000	0.06495
3½	10	3.500	3.4350	3.3701	0.1000000	0.06495
4	10	4.000	3.9350	3.8701	0.1000000	0.06495
4½	10	4.500	4.4350	4.3701	0.1000000	0.06495
5	10	5.000	4.9350	4.8701	0.1000000	0.06495
5½	10	5.500	5.4350	5.3701	0.1000000	0.06495
6	10	6.000	5.9350	5.8701	0.1000000	0.06495

All dimensions in inches.

<sup>1</sup>This column is given to seven decimal places for computation purposes only.

TABLE 20—FREE FIT (CLASS C) FOR SCREWS IN THE FINE-THREAD SERIES OVER 1½-IN. DIAMETER

Size	Threads per Inch	Major Diameter			Pitch Diameter			Maximum Minor Diameter
		Maximum <sup>1</sup>	Tolerance	Minimum	Maximum <sup>1</sup>	Tolerance <sup>2</sup>	Minimum	
1¼	12	1.7500	0.0112	1.7388	1.6959	0.0055	1.6904	1.6478
2	12	2.0000	0.0112	1.9888	1.9459	0.0057	1.9402	1.8978
2¼	12	2.2500	0.0112	2.2388	2.1959	0.0059	2.1900	2.1478
2½	12	2.5000	0.0112	2.4888	2.4459	0.0060	2.4399	2.3978
2¾	12	2.7500	0.0112	2.7388	2.6959	0.0062	2.6897	2.6478
3	10	3.0000	0.0128	2.9872	2.9350	0.0066	2.9284	2.8773
3½	10	3.5000	0.0128	3.4872	3.4350	0.0069	3.4281	3.3773
4	10	4.0000	0.0128	3.9872	3.9350	0.0072	3.9278	3.8773
4½	10	4.5000	0.0128	4.4872	4.4350	0.0074	4.4276	4.3773
5	10	5.0000	0.0128	4.9872	4.9350	0.0076	4.9274	4.8773
5½	10	5.5000	0.0128	5.4872	5.4350	0.0078	5.4272	5.3773
6	10	6.0000	0.0128	5.9872	5.9350	0.0081	5.9269	5.8773

All dimensions in inches.

<sup>1</sup>Basic diameter.<sup>2</sup>The tolerances specified for pitch diameter are cumulative and include errors of lead and angle.<sup>3</sup>Dimensions given are figured to the intersection of the worn tool arc with a centerline through crest and root. Minimum flat at root equals ¼ x p.

TABLE 21—FREE FIT (CLASS C) FOR NUTS IN THE FINE-THREAD SERIES OVER 1½-IN. DIAMETER

Size	Threads per Inch	Minimum Major Diameter <sup>1</sup>	Pitch Diameter		Minor Diameter			Maximum
			Minimum <sup>2</sup>	Tolerance <sup>3</sup>	Maximum	Minimum	Tolerance	
1¼	12	1.7500	1.6959	0.0055	1.7014	1.6598	0.0090	1.6688
2	12	2.0000	1.9459	0.0057	1.9516	1.9098	0.0090	1.9188
2¼	12	2.2500	2.1959	0.0059	2.2018	2.1598	0.0090	2.1688
2½	12	2.5000	2.4459	0.0060	2.4519	2.4098	0.0090	2.4188
2¾	12	2.7500	2.6959	0.0062	2.7019	2.6598	0.0090	2.6688
3	10	3.0000	2.9350	0.0066	2.9416	2.8917	0.0108	2.9025
3½	10	3.5000	3.4350	0.0069	3.4419	3.3917	0.0108	3.4025
4	10	4.0000	3.9350	0.0072	3.9422	3.8917	0.0108	3.9025
4½	10	4.5000	4.4350	0.0074	4.4424	4.3917	0.0108	4.4025
5	10	5.0000	4.9350	0.0076	4.9426	4.8917	0.0108	4.9025
5½	10	5.5000	5.4350	0.0078	5.4428	5.3917	0.0108	5.4025
6	10	6.0000	5.9350	0.0081	5.9431	5.8917	0.0108	5.9025

All dimensions in inches.

<sup>1</sup>Basic diameter. Dimensions given are allowable only with tap having theoretically sharp corners. Threaded hole must not reject correct basic "Go" gage by interference with rounded roots due to worn tap. Minimum flat at root equals 1/24 x p.<sup>2</sup>Basic diameter.<sup>3</sup>The tolerances specified for pitch diameter are cumulative and include errors of lead and angle.

Tolerances for screw-threads of special diameters and pitches with lengths of engagement of not over six threads may be obtained by adding the pitch and diameter increments from Tables 24 to 27 inclusive, which are in agreement with the 1924 Report of the National Screw Thread Commission. Tables 15 to 19 inclusive, giving the tolerances for the S.A.E. Extra-Fine Screw-Thread Series, and Tables 20 to 23 inclu-

TABLE 22—MEDIUM FIT (CLASS D) FOR SCREWS IN THE FINE-THREAD SERIES OVER 1½-IN. DIAMETER

Size	Threads per Inch	Major Diameter			Pitch Diameter			Maximum Minor Diameter
		Maximum <sup>1</sup>	Tolerance	Minimum	Maximum	Tolerance <sup>2</sup>	Minimum	
1¼	12	1.7500	0.0112	1.7388	1.6959	0.0041	1.6918	1.6478
2	12	2.0000	0.0112	1.9888	1.9459	0.0043	1.9416	1.8978
2¼	12	2.2500	0.0112	2.2388	2.1959	0.0044	2.1915	2.1478
2½	12	2.5000	0.0112	2.4888	2.4459	0.0046	2.4413	2.3978
2¾	12	2.7500	0.0112	2.7388	2.6959	0.0048	2.6911	2.6478
3	10	3.0000	0.0128	2.9872	2.9350	0.0050	2.9309	2.8773
3½	10	3.5000	0.0128	3.4872	3.4350	0.0053	3.4297	3.3773
4	10	4.0000	0.0128	3.9872	3.9350	0.0056	3.9294	3.8773
4½	10	4.5000	0.0128	4.4872	4.4350	0.0059	4.4292	4.3773
5	10	5.0000	0.0128	4.9872	4.9350	0.0060	4.9290	4.8773
5½	10	5.5000	0.0128	5.4872	5.4350	0.0063	5.4287	5.3773
6	10	6.0000	0.0128	5.9872	5.9350	0.0065	5.9285	5.8773

All dimensions in inches.

<sup>1</sup>Basic diameter.<sup>2</sup>The tolerances specified for pitch diameter are cumulative and include errors of lead and angle.<sup>3</sup>Dimensions given are figured to the intersection of the worn tool arc with a centerline through crest and root. Minimum flat at root equals ¼ x p.

TABLE 23—MEDIUM FIT (CLASS D) FOR NUTS IN THE FINE-THREAD SERIES OVER 1½-IN. DIAMETER

Size	Threads per Inch	Minimum Major Diameter <sup>1</sup>	Pitch Diameter			Minor Diameter		
			Minimum <sup>2</sup>	Tolerance <sup>3</sup>	Maximum	Minimum	Tolerance	Maximum
1¼	12	1.7500	1.6959	0.0041	1.7000	1.6598	0.0090	1.6688
2	12	2.0000	1.9459	0.0043	1.9502	1.9098	0.0090	1.9188
2¼	12	2.2500	2.1959	0.0044	2.2003	2.1598	0.0090	2.1688
2½	12	2.5000	2.4459	0.0046	2.4505	2.4098	0.0090	2.4188
2¾	12	2.7500	2.6959	0.0048	2.7007	2.6598	0.0090	2.6688
3	10	3.0000	2.9350	0.0050	2.9400	2.8917	0.0108	2.9025
3½	10	3.5000	3.4350	0.0053	3.4403	3.3917	0.0108	3.4025
4	10	4.0000	3.9350	0.0056	3.9406	3.8917	0.0108	3.9025
4½	10	4.5000	4.4350	0.0059	4.4408	4.3917	0.0108	4.4025
5	10	5.0000	4.9350	0.0060	4.9410	4.8917	0.0108	4.9025
5½	10	5.5000	5.4350	0.0063	5.4413	5.3917	0.0108	5.4025
6	10	6.0000	5.9350	0.0065	5.9415	5.8917	0.0108	5.9025

All dimensions in inches.

<sup>1</sup>Basic diameter. Dimensions given are allowable only with tap having theoretically sharp corners. Threaded hole must not reject correct basic "Go" gage by interference with rounded roots due to worn tap. Minimum flat at root equals 1/24 x p.<sup>2</sup>Basic diameter.<sup>3</sup>The tolerances specified for pitch diameter are cumulative and include errors of lead and angle.

TABLE 24—CLASS C PITCH INCREMENTS

Number of Threads per Inch	Pitch Diameter Tolerance, Pitch Increment	Screw		Nut		
		Tolerance on Major Diameter, Minus	Maximum Minor Diameter, Maximum Major Diameter, Minus	Maximum Pitch Diameter, Maximum Major Diameter, Minus	Tolerance on Minor Diameter, Plus	Minimum Minor Diameter, Basic Major Diameter, Minus
64	0.00125	0.0038	0.0192	0.0101	0.0017	0.0169
56	0.00134	0.0040	0.0219	0.0116	0.0019	0.0183
48	0.00144	0.0044	0.0256	0.0135	0.0023	0.0206
40	0.00155	0.0048	0.0307	0.0162	0.0027	0.0239
36	0.00167	0.0050	0.0341	0.0180	0.0030	0.0261
32	0.00177	0.0054	0.0383	0.0203	0.0034	0.0293
28	0.00189	0.0062	0.0438	0.0232	0.0039	0.0327
24	0.00204	0.0066	0.0511	0.0271	0.0045	0.0371
20	0.00224	0.0072	0.0613	0.0325	0.0054	0.0435
18	0.00236	0.0082	0.0682	0.0361	0.0060	0.0481
16	0.00250	0.0090	0.0767	0.0406	0.0068	0.0539
14	0.00267	0.0098	0.0876	0.0464	0.0077	0.0604
12	0.00289	0.0112	0.1022	0.0541	0.0090	0.0692
10	0.00316	0.0128	0.1227	0.0650	0.0108	0.0809
8	0.00354	0.0152	0.1534	0.0812	0.0135	0.0952
6	0.00408	0.0202	0.2045	0.1083	0.0180	0.1263
4	0.00500	0.0280	0.3067	0.1624	0.0271	0.1895

All dimensions in inches.

sive, giving the tolerances for the Fine Screw-Thread Series above the 1½-in. diameter, have been computed in this manner.

## STANDARDS COMMITTEE DIVISION REPORTS

431

TABLE 25—CLASS C DIAMETER INCREMENTS OF PITCH-DIAMETER TOLERANCES

Diameter	Diameter Increment
0.0625	0.00050
0.125	0.00071
0.1875	0.00087
0.250	0.00100
0.375	0.00122
0.500	0.00141
0.750	0.00173
1.000	0.00200
1.500	0.00245
2.000	0.00283
3.000	0.00346
4.000	0.00400
6.000	0.00490
8.000	0.00566
12.000	0.00693

All dimensions in inches.

TABLE 26—CLASS D PITCH INCREMENTS

Number of Threads per Inch	Pitch Diameter Tolerance, Pitch Increment	Screw			Nut		
		Tolerance on Major Diameter, Minus	Maximum Minor Diameter = Maximum Major Diameter, Minus	Maximum Pitch Diameter = Maximum Major Diameter, Minus	Tolerance on Minor Diameter, Plus	Minimum Minor Diameter = Basic Major Diameter, Minus	Minimum Pitch Diameter = Minimum Major Diameter, Minus
64	0.00062	0.0038	0.0192	0.0101	0.0017	0.0169	0.0101
56	0.00067	0.0040	0.0219	0.0116	0.0019	0.0193	0.0116
48	0.00072	0.0044	0.0256	0.0135	0.0023	0.0226	0.0135
40	0.00079	0.0048	0.0307	0.0162	0.0027	0.0271	0.0162
36	0.00083	0.0050	0.0341	0.0180	0.0030	0.0301	0.0180
32	0.00088	0.0054	0.0383	0.0203	0.0034	0.0338	0.0203
28	0.00094	0.0062	0.0438	0.0232	0.0039	0.0387	0.0232
24	0.00102	0.0066	0.0511	0.0271	0.0045	0.0451	0.0271
20	0.00112	0.0072	0.0613	0.0325	0.0054	0.0541	0.0325
18	0.00118	0.0082	0.0682	0.0361	0.0060	0.0601	0.0361
16	0.00125	0.0090	0.0767	0.0406	0.0068	0.0677	0.0406
14	0.00133	0.0098	0.0876	0.0464	0.0077	0.0773	0.0464
12	0.00144	0.0112	0.1022	0.0541	0.0090	0.0902	0.0541
10	0.00158	0.0128	0.1227	0.0650	0.0108	0.1083	0.0650
8	0.00177	0.0152	0.1534	0.0812	0.0135	0.1353	0.0812
6	0.00204	0.0202	0.2045	0.1083	0.0180	0.1804	0.1083
4	0.00250	0.0280	0.3067	0.1624	0.0271	0.2706	0.1624

All dimensions in inches.

TABLE 27—CLASS D DIAMETER INCREMENTS OF PITCH-DIAMETER TOLERANCES

Diameter	Diameter Increment
0.0625	0.00050
0.1250	0.00071
0.1875	0.00087
0.2500	0.00100
0.3750	0.00122
0.5000	0.00141
0.7500	0.00173
1.0000	0.00200
1.5000	0.00245
2.0000	0.00283
3.0000	0.00346
4.0000	0.00400
6.0000	0.00490
8.0000	0.00566
12.0000	0.00693

All dimensions in inches.

## EXTRA-FINE THREAD FIT APPLICATIONS

## Supplementary Report Completes Present Information on Screw-Thread Fits

The following extra-fine screw-thread fit applications have been recommended by the Screw-Threads Division for S.A.E. Specifications using extra-fine screw-threads. This recommendation completes the report of the Screw-Threads Division covering fits for screw-threads specified in the S.A.E. Standards and Recommended Practices.

## EXTRA-FINE SCREW-THREAD FIT APPLICATIONS

Data Sheet	Class	Fit Classification
C13	Square Fittings	EF-C
C15	Taper Fittings	EF-C
C46	Fuel and Lubrication Tube Fittings (Soldered and Flared Types Only)	EF-C
C57	Oil and Grease-Cup Threads	EF-C
C58a	Tank and Radiator Caps	EF-C
C75	Tachometer Drive	EF-D
J4	Steering-Wheel Hubs	EF-C

As the extra-fine series is not included in the American Standard for Screw-Threads, the letters EF are used to designate the series, corresponding to NC for the coarse screw-thread series and NF for the fine screw-thread series. The letters C and D refer to the Free and Medium Fits respectively.

Screw-thread fit applications for the coarse and fine-thread series are printed on p. C1n of the S.A.E. HANDBOOK. As the specifications in the S.A.E. HANDBOOK are revised, the fits recommended by the Screw-Threads Division will be included in the specifications.

## SECTIONAL COMMITTEE REPORT APPROVED

## Wrench-Head Bolts and Nuts and Wrench Openings Proposed for S.A.E. Standard

The report of the Sectional Committee on the Standardization of Bolt, Nut and Rivet Proportions, covering the proposed Tentative American Standard for Wrench-Head Bolts and Nuts and Wrench Openings, submitted for approval by the Society was referred to the Screw-Threads Division at the April meeting in accordance with the usual standardization procedure in approving Sectional Committee Reports. The report was drawn up by Subcommittee No. 2, under the chairmanship of Com. J. B. Rhodes, U. S. N., the complete personnel being as follows:

Com. J. B. Rhodes, U.S.N.

Hugh Aikman  
Major G. M. Barnes,  
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Chairman, Naval Gun  
Factory  
J. H. Williams & Co.  
Ordnance Department

Billings & Spencer Co.  
Russell, Burdsall & Ward  
Bolt & Nut Co.  
Electric Power Club  
Bridgeport, Conn.  
Bethlehem Steel Co.  
Standard Screw Co.  
Bethlehem Shipbuilding  
Corporation  
Hill Pump Valve Co.  
International Motor Co.  
Landis Machine Co.  
Greenfield, Mass.  
Pheoll Mfg. Co.  
International Harvester  
Co.

TABLE 1—ROUGH AND SEMI-FINISHED SQUARE AND HEXAGONAL REGULAR BOLT-HEADS

Diameter of Bolt		Width Across Flats			Minimum Width Across Corners		Height		
Nominal	Maximum	Nominal	Maximum	Minimum	Hexagon	Square	Nominal	Maximum	Minimum
$\frac{1}{4}$	0.2500	$\frac{3}{8}$	0.3750	0.363	0.414	0.498	$\frac{11}{64}$	0.188	0.156
$\frac{5}{16}$	0.3125	$\frac{1}{2}$	0.5000	0.484	0.552	0.665	$\frac{13}{64}$	0.220	0.186
$\frac{3}{8}$	0.3750	$\frac{9}{16}$	0.5625	0.544	0.620	0.747	$\frac{1}{4}$	0.268	0.232
$\frac{7}{16}$	0.4375	$\frac{5}{8}$	0.6250	0.603	0.687	0.828	$\frac{19}{64}$	0.316	0.278
$\frac{1}{2}$	0.5000	$\frac{3}{4}$	0.7500	0.725	0.827	0.995	$\frac{21}{64}$	0.384	0.308
$\frac{9}{16}$	0.5625	$\frac{7}{8}$	0.8750	0.847	0.966	1.163	$\frac{3}{8}$	0.396	0.354
$\frac{5}{8}$	0.6250	$\frac{15}{16}$	0.9375	0.906	1.033	1.244	$\frac{27}{64}$	0.444	0.400
$\frac{3}{4}$	0.7500	$1\frac{1}{8}$	1.1250	1.088	1.240	1.494	$\frac{1}{2}$	0.524	0.476
$\frac{7}{8}$	0.8750	$1\frac{1}{4}$	1.3125	1.269	1.447	1.742	$\frac{19}{32}$	0.620	0.568
1	1.0000	$1\frac{1}{2}$	1.5000	1.450	1.653	1.991	$\frac{21}{32}$	0.684	0.628
$1\frac{1}{8}$	1.1250	$1\frac{11}{16}$	1.6875	1.631	1.859	2.239	$\frac{3}{4}$	0.780	0.720
$1\frac{1}{4}$	1.2500	$1\frac{7}{8}$	1.8750	1.813	2.067	2.489	$\frac{27}{32}$	0.876	0.812
$1\frac{1}{2}$	1.5000	$2\frac{1}{4}$	2.2500	2.175	2.480	2.986	1	1.036	0.964
$1\frac{3}{4}$	1.7500	$2\frac{5}{8}$	2.6250	2.538	2.893	3.485	$1\frac{1}{2}$	1.196	1.116
2	2.0000	3	3.0000	2.900	3.306	3.982	$1\frac{11}{32}$	1.388	1.300
$2\frac{1}{4}$	2.2500	$3\frac{3}{8}$	3.3750	3.263	3.720	4.480	$1\frac{1}{2}$	1.548	1.452
$2\frac{1}{2}$	2.5000	$3\frac{3}{4}$	3.7500	3.625	4.132	4.977	$1\frac{21}{32}$	1.708	1.604
$2\frac{3}{4}$	2.7500	$4\frac{1}{8}$	4.1250	3.988	4.546	5.476	$1\frac{57}{64}$	1.885	1.773
3	3.0000	$4\frac{1}{2}$	4.5000	4.350	4.959	5.973	2	2.060	1.960

All dimensions in inches.

The top of the bolt-head shall be flat and chamfered, angle of chamfer with top surface 30 deg.; diameter of top flat circle shall be 100 per cent of the nominal width across flats. Tolerance on top flat circle shall be minus 15 per cent.

Rough and semi-finished regular bolt-heads shall be at right angles to the body within 3 deg. and concentric with the body within a tolerance of 3 per cent of the distance across flats.

Width across flats shall be measured at the bottom of the bolt-head. Taper of sides of bolt-heads shall not exceed 4 deg.

TABLE 2—FINISHED SQUARE AND HEXAGONAL BOLT-HEADS

Diameter of Bolt		Width Across Flats			Minimum Width Across Corners		Height		
Nominal	Maximum	Nominal	Maximum	Minimum	Hexagon	Square	Nominal	Maximum	Minimum
$\frac{1}{4}$	0.2500	$\frac{7}{16}$	0.4375	0.428	0.488	0.588	$\frac{3}{16}$	0.194	0.180
$\frac{5}{16}$	0.3125	$\frac{9}{16}$	0.5625	0.552	0.628	0.757	$\frac{15}{64}$	0.242	0.227
$\frac{3}{8}$	0.3750	$\frac{5}{8}$	0.6250	0.613	0.699	0.840	$\frac{9}{32}$	0.289	0.273
$\frac{7}{16}$	0.4375	$\frac{3}{4}$	0.7500	0.737	1.840	1.012	$\frac{21}{64}$	0.337	0.319
$\frac{1}{2}$	0.5000	$\frac{13}{16}$	0.8125	0.799	0.911	1.096	$\frac{3}{8}$	0.385	0.365
$\frac{9}{16}$	0.5625	$\frac{7}{8}$	0.8750	0.860	0.980	1.181	$\frac{27}{64}$	0.433	0.411
$\frac{5}{8}$	0.6250	$\frac{15}{8}$	0.9375	0.922	1.052	1.266	$\frac{19}{32}$	0.481	0.457
$\frac{3}{4}$	0.7500	$1\frac{1}{8}$	1.1250	1.107	1.263	1.519	$\frac{9}{16}$	0.576	0.549
$\frac{7}{8}$	0.8750	$1\frac{1}{4}$	1.3125	1.293	1.474	1.775	$\frac{21}{32}$	0.672	0.641
1	1.0000	$1\frac{1}{2}$	1.5000	1.479	1.686	2.031	$\frac{3}{4}$	0.768	0.733
$1\frac{1}{8}$	1.1250	$1\frac{11}{16}$	1.6875	1.665	1.898	2.286	$\frac{27}{32}$	0.863	0.824
$1\frac{1}{4}$	1.2500	$1\frac{7}{8}$	1.8750	1.850	2.109	2.540	$\frac{15}{16}$	0.959	0.916
$1\frac{1}{2}$	1.5000	$2\frac{1}{4}$	2.2500	2.222	2.534	3.051	$1\frac{1}{4}$	1.150	1.100
$1\frac{3}{4}$	1.7500	$2\frac{5}{8}$	2.6250	2.593	2.955	3.560	$1\frac{1}{2}$	1.341	1.284
2	2.0000	3	3.0000	2.964	3.379	4.070	$1\frac{1}{2}$	1.533	1.468
$2\frac{1}{4}$	2.2500	$3\frac{3}{8}$	3.3750	3.335	3.802	4.579	$1\frac{11}{16}$	1.724	1.651
$2\frac{1}{2}$	2.5000	$3\frac{3}{4}$	3.7500	3.707	4.226	5.090	$1\frac{7}{8}$	1.915	1.835
$2\frac{3}{4}$	2.7500	$4\frac{1}{8}$	4.1250	4.078	4.646	5.599	$2\frac{1}{16}$	2.106	2.019
3	3.0000	$4\frac{1}{2}$	4.5000	4.449	5.072	6.108	$2\frac{1}{4}$	2.298	2.203

All dimensions in inches.

The finished top shall be flat and chamfered; angle of chamfer with top surface 30 deg.; diameter of top flat circle shall be 100 per cent of the nominal width across flats. Tolerance on top flat circle shall be minus 15 per cent.

Finished bolt-heads shall be at right angles to the body within 2 deg. and concentric with the body within a tolerance of 3 per cent of the distance across the flats.

All finished bolts shall be washer-faced, the thickness of the washer-face shall be the distance from the top of the head to the bearing surface.

The thickness of the washer-face shall be  $\frac{1}{64}$  in.

The bearing surface of the washer-face shall equal the width across flats with a plus or minus tolerance of 5 per cent.

## STANDARDS COMMITTEE DIVISION REPORTS

433

TABLE 3—FINISHED HEXAGONAL CAP-SCREW HEADS

Diameter of Screw		Width Across Flats			Minimum Width Across Corners	Height		
Nominal	Maximum	Nominal	Maximum	Minimum		Nominal	Maximum	Minimum
$\frac{1}{4}$	0.2500	$\frac{7}{16}$	0.4375	0.428	0.488	$\frac{3}{16}$	0.194	0.181
$\frac{5}{16}$	0.3125	$\frac{1}{2}$	0.5000	0.489	0.558	$\frac{15}{64}$	0.242	0.227
$\frac{3}{8}$	0.3750	$\frac{9}{16}$	0.5625	0.551	0.628	$\frac{5}{32}$	0.289	0.274
$\frac{7}{16}$	0.4375	$\frac{5}{8}$	0.6250	0.612	0.699	$\frac{21}{64}$	0.337	0.319
$\frac{1}{2}$	0.5000	$\frac{3}{4}$	0.7500	0.737	0.840	$\frac{3}{8}$	0.385	0.365
$\frac{9}{16}$	0.5625	$\frac{13}{16}$	0.8125	0.798	0.910	$\frac{27}{64}$	0.433	0.411
$\frac{5}{8}$	0.6250	$\frac{7}{8}$	0.8750	0.860	0.980	$\frac{15}{32}$	0.481	0.457
$\frac{3}{4}$	0.7500	1	1.0000	0.983	1.120	$\frac{9}{16}$	0.576	0.549
$\frac{7}{8}$	0.8750	$1\frac{1}{8}$	1.1250	1.106	1.261	$\frac{21}{32}$	0.672	0.641
1	1.0000	$1\frac{1}{4}$	1.3125	1.291	1.474	$\frac{3}{4}$	0.768	0.733
$1\frac{1}{8}$	1.1250	$1\frac{1}{2}$	1.5000	1.477	1.686	$\frac{27}{32}$	0.863	0.824
$1\frac{1}{4}$	1.2500	$1\frac{3}{4}$	1.6875	1.663	1.898	$\frac{15}{16}$	0.959	0.916

All dimensions in inches.

The finished top shall be flat and chamfered, angle of chamfer with top surface 30 deg.; diameter of top flat circle shall be 100 per cent of the nominal width across flats. Tolerance in diameter of top flat circle shall be minus 15 per cent.

Cap-screw heads shall be at right angles to the body within 2 deg. and concentric with the body within a tolerance of 3 per cent of the distance across the flats.

All cap-screws shall be washer-faced. The thickness of the washer-face shall be the distance from the top of the head to the bearing surface. The thickness of the washer-face shall be  $\frac{1}{64}$  in. The bearing surface of the washer-face shall be 100 per cent of the nominal width across flats. Tolerance in diameter of circle of washer-face shall be plus or minus 5 per cent.

TABLE 5—ROUGH AND SEMI-FINISHED SQUARE AND HEXAGONAL REGULAR NUTS

Diameter of Bolt		Width Across Flats			Minimum Width Across Corners		Thickness		
Nominal	Maximum	Nominal	Maximum	Minimum	Hexagon	Square	Nominal	Maximum	Minimum
$\frac{1}{4}$	0.2500	$\frac{7}{16}$	0.4375	0.425	0.485	0.584	$\frac{7}{32}$	0.235	0.203
$\frac{5}{16}$	0.3125	$\frac{9}{16}$	0.5625	0.547	0.624	0.751	$\frac{17}{64}$	0.283	0.249
$\frac{3}{8}$	0.3750	$\frac{5}{8}$	0.6250	0.606	0.691	0.832	$\frac{21}{64}$	0.346	0.310
$\frac{7}{16}$	0.4375	$\frac{3}{4}$	0.7500	0.728	0.830	1.000	$\frac{3}{8}$	0.394	0.356
$\frac{1}{2}$	0.5000	$\frac{13}{16}$	0.8125	0.788	0.898	1.082	$\frac{7}{16}$	0.458	0.418
$\frac{9}{16}$	0.5625	$\frac{7}{8}$	0.8750	0.847	0.966	1.163	$\frac{31}{64}$	0.505	0.463
$\frac{5}{8}$	0.6250	$\frac{15}{16}$	0.9375	0.906	1.033	1.244	$\frac{35}{64}$	0.569	0.525
$\frac{3}{4}$	0.7500	$1\frac{1}{8}$	1.1250	1.088	1.240	1.494	$\frac{21}{32}$	0.680	0.632
$\frac{7}{8}$	0.8750	$1\frac{1}{4}$	1.3125	1.269	1.447	1.742	$\frac{49}{64}$	0.792	0.740
1	1.0000	$1\frac{1}{2}$	1.5000	1.450	1.653	1.991	$\frac{7}{8}$	0.903	0.847
$1\frac{1}{8}$	1.1250	$1\frac{3}{4}$	1.6875	1.631	1.859	2.239	1	1.030	0.970
$1\frac{1}{4}$	1.2500	$2\frac{1}{8}$	1.8750	1.813	2.067	2.489	$1\frac{1}{8}$	1.126	1.062
$1\frac{1}{2}$	1.5000	$2\frac{1}{4}$	2.2500	2.175	2.480	2.986	$1\frac{5}{16}$	1.349	1.277
$1\frac{3}{4}$	1.7500	$2\frac{5}{8}$	2.6250	2.538	2.893	3.485	$1\frac{17}{32}$	1.571	1.491
2	2.0000	3	3.0000	2.900	3.306	3.982	$1\frac{3}{4}$	1.794	1.706
$2\frac{1}{4}$	2.2500	$3\frac{3}{8}$	3.3750	3.263	3.720	4.480	$1\frac{31}{32}$	2.017	1.921
$2\frac{1}{2}$	2.5000	$3\frac{1}{2}$	3.7500	3.625	4.133	4.977	$2\frac{3}{16}$	2.240	2.136
$2\frac{3}{4}$	2.7500	$4\frac{1}{8}$	4.1250	3.988	4.546	5.476	$2\frac{13}{32}$	2.350	2.462
3	3.0000	$4\frac{1}{2}$	4.5000	4.350	4.959	5.973	$2\frac{5}{8}$	2.685	2.565

All dimensions in inches.

The top of rough and semi-finished regular square and hexagonal nuts shall be flat and chamfered, angle of chamfer with surface 30 deg.; diameter of top, or both top and bottom circle, shall be 100 per cent of the nominal width across flats. Tolerance on top flat circle shall be minus 15 per cent.

Semi-finished nuts shall be faced on bearing surface and at right angles to the axis of the thread within 3 deg.

Width across flats to be measured at the top of the nut.

Taper of sides of nuts not to exceed 4 deg.

TABLE 6—FINISHED SQUARE AND HEXAGONAL REGULAR NUTS

Diameter of Bolt		Width Across Flats			Minimum Width Across Corners		Thickness		
Nominal	Maximum	Nominal	Maximum	Minimum	Hexagon	Square	Nominal	Maximum	Minimum
$\frac{1}{4}$	0.2500	$\frac{7}{16}$	0.4375	0.428	0.488	0.588	$\frac{7}{32}$	0.225	0.212
$\frac{5}{16}$	0.3125	$\frac{9}{16}$	0.5625	0.552	0.628	0.757	$\frac{17}{64}$	0.273	0.258
$\frac{3}{8}$	0.3750	$\frac{5}{8}$	0.6250	0.613	0.698	0.840	$\frac{21}{64}$	0.336	0.320
$\frac{7}{16}$	0.4375	$\frac{3}{4}$	0.7500	0.737	0.840	1.012	$\frac{3}{8}$	0.384	0.366
$\frac{1}{2}$	0.5000	$\frac{13}{16}$	0.8125	0.799	0.911	1.096	$\frac{7}{16}$	0.448	0.428
$\frac{9}{16}$	0.5625	$\frac{7}{8}$	0.8750	0.860	0.980	1.181	$\frac{31}{64}$	0.495	0.473
$\frac{5}{8}$	0.6250	$\frac{15}{16}$	0.9375	0.922	1.051	1.266	$\frac{35}{64}$	0.559	0.535
$\frac{3}{4}$	0.7500	$1\frac{1}{8}$	1.1250	1.108	1.263	1.517	$\frac{21}{32}$	0.670	0.642
$\frac{7}{8}$	0.8750	$1\frac{1}{16}$	1.3125	1.293	1.474	1.775	$\frac{49}{64}$	0.781	0.750
1	1.0000	$1\frac{1}{2}$	1.5000	1.479	1.686	2.031	$\frac{7}{8}$	0.893	0.858
$1\frac{1}{8}$	1.1250	$1\frac{13}{16}$	1.6875	1.665	1.898	2.286	1	1.019	0.981
$1\frac{1}{4}$	1.2500	$1\frac{7}{8}$	1.8750	1.850	2.109	2.540	$1\frac{3}{32}$	1.115	1.072
$1\frac{1}{2}$	1.5000	$2\frac{1}{4}$	2.2500	2.222	2.533	3.051	$1\frac{15}{16}$	1.338	1.288
$1\frac{3}{4}$	1.7500	$2\frac{5}{8}$	2.6250	2.593	2.956	3.560	$1\frac{17}{32}$	1.560	1.503
2	2.0000	3	3.0000	2.964	3.379	4.070	$1\frac{3}{4}$	1.783	1.718
$2\frac{1}{4}$	2.2500	$3\frac{3}{8}$	3.3750	3.335	3.802	4.579	$1\frac{31}{32}$	2.005	1.932
$2\frac{1}{2}$	2.5000	$3\frac{7}{8}$	3.7500	3.707	4.226	5.090	$2\frac{3}{16}$	2.228	2.148
$2\frac{3}{4}$	2.7500	$4\frac{1}{8}$	4.1250	4.078	4.646	5.599	$2\frac{13}{32}$	2.450	2.363
3	3.0000	$4\frac{1}{2}$	4.5000	4.449	5.072	6.108	$2\frac{5}{8}$	2.673	2.578

All dimensions in inches.

The finished top of finished nuts shall be flat and chamfered, angle of chamfer with surface 30 deg.; diameter of top, or both top and bottom circle, shall be 100 per cent of the nominal width across flats. Tolerance on top flat circle shall be minus 15 per cent.

All finished hexagon and square regular nuts shall be washer-faced; the thickness of the washer-face shall be  $\frac{1}{64}$  in. The bearing surface of the washer-face shall be 100 per cent of the nominal width across flats. Tolerance on the diameter of the washer-face shall be plus or minus 5 per cent.

The axis of the threaded hole shall be at right angles to the washer-face within a tolerance of 2 deg.

TABLE 8—HEXAGON LIGHT NUTS

Diameter of Bolt		Width Across Flats			Minimum Width Across Corners		Thickness		
Nominal	Maximum	Nominal	Maximum	Minimum	Hexagon	Square	Nominal	Maximum	Minimum
$\frac{1}{4}$	0.2500	$\frac{7}{16}$	0.4375	0.428	0.488	0.588	$\frac{7}{32}$	0.225	0.212
$\frac{5}{16}$	0.3125	$\frac{1}{2}$	0.5000	0.489	0.557	0.671	$\frac{17}{64}$	0.273	0.259
$\frac{3}{8}$	0.3750	$\frac{9}{16}$	0.5625	0.551	0.628	0.757	$\frac{21}{64}$	0.336	0.320
$\frac{7}{16}$	0.4375	$\frac{5}{8}$	0.6250	0.612	0.699	0.840	$\frac{3}{8}$	0.384	0.366
$\frac{1}{2}$	0.5000	$\frac{3}{4}$	0.7500	0.737	0.840	1.012	$\frac{7}{16}$	0.488	0.428

All dimensions in inches.

Light nuts are recommended for use with fine screw-threads only.

The finished tops of the nuts, when not castellated, shall be flat and chamfered, angle of chamfer with top surface 30 deg.; diameter of top flat circle shall be 100 per cent of the nominal width across flats. Tolerance on top flat circle shall be minus 15 per cent.

Nuts shall be washer-faced. The thickness of the washer-face shall be  $\frac{1}{64}$  in. The bearing surface of the washer-face shall be 100 per cent of the nominal width across flats. Tolerance on diameter of washer-face shall be plus or minus 5 per cent.

TABLE 9—HEXAGONAL AND SQUARE MACHINE-SCREW AND STOVE-BOLT NUTS

Diameter of Screw		Width Across Flats			Minimum Width Across Corners of Hexagon	Thickness		
Nominal	Maximum	Nominal	Maximum	Minimum		Nominal	Maximum	Minimum
No. 0	0.0600	$\frac{3}{32}$	0.1562	0.150	0.171	$\frac{3}{64}$	0.050	0.043
No. 1	0.0730	$\frac{5}{32}$	0.1562	0.150	0.171	$\frac{3}{64}$	0.050	0.043
No. 2	0.0860	$\frac{3}{16}$	0.1875	0.180	0.205	$\frac{1}{16}$	0.066	0.057
No. 3	0.0990	$\frac{5}{16}$	0.1875	0.180	0.205	$\frac{1}{16}$	0.066	0.057
No. 4	0.1120	$\frac{1}{4}$	0.2500	0.241	0.275	$\frac{3}{32}$	0.098	0.087
No. 5	0.1250	$\frac{5}{16}$	0.3125	0.302	0.344	$\frac{7}{64}$	0.114	0.102
No. 6	0.1380	$\frac{3}{8}$	0.3125	0.302	0.344	$\frac{7}{64}$	0.114	0.102
No. 8	0.1640	$\frac{11}{32}$	0.3437	0.332	0.378	$\frac{1}{8}$	0.130	0.117
No. 10	0.1900	$\frac{3}{8}$	0.3750	0.362	0.413	$\frac{1}{8}$	0.130	0.117
No. 12	0.2160	$\frac{7}{16}$	0.4375	0.423	0.482	$\frac{5}{32}$	0.161	0.148
$\frac{1}{4}$	0.2500	$\frac{7}{16}$	0.4375	0.423	0.482	$\frac{3}{16}$	0.193	0.178
$\frac{5}{16}$	0.3125	$\frac{9}{16}$	0.5625	0.545	0.621	$\frac{7}{32}$	0.225	0.208
$\frac{3}{8}$	0.3750	$\frac{5}{8}$	0.6250	0.607	0.692	$\frac{1}{4}$	0.257	0.239
$\frac{7}{16}$	0.4375	$\frac{3}{4}$	0.7500	0.729	0.831	$\frac{9}{32}$	0.289	0.269
$\frac{1}{2}$	0.5000	$\frac{13}{16}$	0.8125	0.790	0.901	$\frac{5}{16}$	0.321	0.299

All dimensions in inches.

## STANDARDS COMMITTEE DIVISION REPORTS

435

TABLE 10—OPEN-END WRENCH OPENINGS

Basic Width Across Flats of Bolt Heads and Nuts		Clearance	Tolerance	Dimensions of Measuring Blocks for Wrench Openings	
Nominal	Maximum			Maximum	Minimum
$\frac{1}{2}$	0.1562	0.0014	0.005	0.163	0.158
$\frac{3}{8}$	0.1875	0.0016	0.005	0.194	0.189
$\frac{1}{4}$	0.2500	0.0018	0.005	0.257	0.252
$\frac{5}{16}$	0.3125	0.0019	0.007	0.321	0.314
$\frac{11}{16}$	0.3437	0.0022	0.007	0.353	0.346
$\frac{3}{4}$	0.3750	0.0024	0.007	0.384	0.377
$\frac{7}{8}$	0.4375	0.0025	0.007	0.447	0.440
$\frac{1}{2}$	0.5000	0.0030	0.007	0.510	0.503
$\frac{5}{8}$	0.5625	0.0035	0.007	0.573	0.566
$\frac{3}{4}$	0.6250	0.0040	0.007	0.636	0.629
$\frac{7}{8}$	0.7500	0.0050	0.008	0.763	0.755
$\frac{1 1/8}$	0.8125	0.0050	0.008	0.826	0.818
$\frac{1 1/4}$	0.8750	0.0050	0.008	0.888	0.880
$\frac{1 3/8}$	0.9375	0.0055	0.009	0.952	0.943
1	1.0000	0.0060	0.009	1.015	1.006
$1 \frac{1}{8}$	1.1250	0.0070	0.010	1.142	1.132
$1 \frac{1}{4}$	1.2500	0.0070	0.010	1.267	1.257
$1 \frac{3}{8}$	1.3125	0.0075	0.011	1.331	1.320
$1 \frac{1}{2}$	1.5000	0.0090	0.012	1.521	1.501
$1 \frac{3}{4}$	1.6875	0.0095	0.013	1.710	1.697
$1 \frac{7}{8}$	1.8750	0.0100	0.013	1.898	1.885
$2 \frac{1}{4}$	2.2500	0.0120	0.015	2.277	2.262
$2 \frac{3}{4}$	2.6250	0.0140	0.017	2.656	2.639
3	3.0000	0.0160	0.019	3.035	3.016
$3 \frac{1}{2}$	3.3750	0.0180	0.021	3.414	3.393
$3 \frac{3}{4}$	3.7500	0.0200	0.023	3.793	3.770
$4 \frac{1}{4}$	4.1250	0.0220	0.024	4.171	4.147
$4 \frac{3}{4}$	4.5000	0.0230	0.026	4.519	4.523

All dimensions in inches.  
The sizes given in the table for the maximum and minimum columns are sizes of "Go" and "No-Go" gage blocks used for inspecting wrenches and are not product sizes.  
Wrenches shall be marked with the basic width (maximum width of nut) across flats.

The following paragraphs, abstracted from the introductory notes to the Sectional Committee Report, give the history of the Subdivision work.

These proposed standards are intended for general use by all industries and the consequent replacement of the various existing standards now in use in these industries. Publicity has been given to the work of the Subcommittee on Wrench-Head Bolts and Nuts and comments have been received from users and manufacturers.

Tables have been circulated and studied both from the point of view of the existing stocks and tools on hand and from the point of view of the theoretically ideal product. As is generally known, the Subcommittee found a large number of standards in use in various parts of the Country and wide variations in practice by both makers and users. The work of foreign standardization committees has been considered and analyzed, but it has been thought by the Committee that the reduced costs of the product as set forth in these tables should outweigh any consideration of increasing bolt-head and nut sizes simply to agree to foreign practice.

The Subcommittee has analyzed existing practice in this Country and has attempted to work out tables of dimensions that will be acceptable to various industries and that will cause least disturbance of present practice. Wherever possible the U. S. Standard sizes of bolt-heads and nuts have been reduced to some existing shop standard after giving consideration to theoretical analysis of stresses in bolts and nuts and making tests of samples. Deviations from theoretical sizes have been made to keep the number of wrench openings small and to conform to certain manufacturing processes. In fixing tolerance it has been difficult to obtain information from manufacturers. Some manufacturers take tolerance from basic size in a plus direction, some in a minus direction and others in both directions. The greatest possible tolerances have been allowed with the realization that they will seldom be found in the product and that the manufacturer will set-up his working gages in such a way as to rob the workmen of part of the tolerance, thus insuring that all the product which is accepted by working gages will easily pass the inspection gage.

It has seemed desirable to reduce the number of wrench openings required, through simplification of outside dimensions of bolt-heads and nuts and elimination of sizes little used. This action tends to reduce the number of sizes of stock for manufacturing that are carried by manufacturers. This has caused deviations from results calculated by formulas for size of bolt heads and nuts due to eliminating the thirty-seconds from all sizes. The S.A.E. Standards had already been published, showing a similar practice.

The sizes of bolt-heads and nuts are intended to supersede all existing standards that have grown up for commercial standard bolt heads and nuts. Special considerations may indicate the need of other sizes and in the practice of certain users there will be specifications for U. S. Standard sizes. It is not expected that these will be carried in stock as a commercial standard but must be specially ordered. These tables are in accordance with the tendency of recent years toward the more economical use of material as expressed in present S.A.E. Standard sizes.

It will be noted that the maximum sizes of both finished and rough products are the same so that wrenches are applicable interchangeably to either class of bolt-head or nut.

In all cases the nominal or basic widths across flats of bolt-heads and nuts have been taken as maximum sizes and the tolerances on bolt-heads and nuts are minus only.

The minimum wrench openings have been made to provide a positive clearance between maximum nut and minimum wrench and the tolerances on wrench openings are plus only. This insures a fit of the wrench to the bolt-head and nut. The tolerance allowed the wrench manufacturer has been made as great as is possible without causing the deformation of the corners of bolt-heads or nuts.

The complete Sectional Committee report covers the following tables of dimensions:

- Table 1—Rough and Semi-Finished Square and Hexagonal Regular Bolt-Heads
- Table 2—Finished Square and Hexagonal Bolt-Heads
- Table 3—Finished Hexagonal Cap-Screw Heads
- Table 4—Set-Screw Heads
- Table 5—Rough and Semi-Finished Square and Hexagonal Nuts
- Table 6—Finished Square and Hexagonal Regular Nuts
- Table 7—Finished and Semi-Finished Jam-Nuts
- Table 8—Hexagon Light Nuts
- Table 9—Hexagonal and Square Machine-Screw and Stove-Bolt Nuts
- Table 10—Open-End Wrench Openings

Tables 4 and 7 are not reprinted as they refer to parts that are not used to a sufficient extent in automotive apparatus to warrant their inclusion in the S.A.E. HANDBOOK. The Screw-Threads Division has recommended that the remaining tables, reprinted herewith, be adopted as S.A.E. Standard and that the present S.A.E. Standard for Screws, Bolts and Nuts, p. C3 of the S.A.E. HANDBOOK, be revised to conform to these tables. The only changes required in the S.A.E. Standard by this recommendation are the widths across flats for the nominal diameters from  $\frac{3}{4}$  to  $1 \frac{1}{2}$  in., which have been increased  $\frac{1}{16}$  in. over the dimensions specified in the S.A.E. Standard.

## CASTLE-NUT STANDARD REVISED

The Screw-Threads Division has issued the accompanying table of castle-nut dimensions based on the present S.A.E. Specification for Castle Nuts, p. C3 of the S.A.E. HANDBOOK, and the report of the Sectional Committee on Bolt, Nut and Rivet Proportions covering wrench-head bolts and nuts. The diameters across the flats for the  $\frac{3}{4}$ -in. size and larger specified in the S.A.E. Standard have been increased to conform to the Sectional Committee Specification for finished nuts and the minimum widths across the corners have been taken from Tables 6 and 8 of the Sectional Committee specifications. The dimensions for the thickness and the width and depth of slot are the same as are specified in the present S.A.E. Standard. The Screw-Threads Division re-

REVISED DIMENSIONS PROPOSED FOR S. A. E. STANDARD CASTLE NUTS

Diameter		Threads per Inch NF-2	Width Across Flats			Minimum Width across Corners	Thickness, Nominal	Slot	
Nominal	Maximum		Nominal	Maximum	Minimum			Width	Depth
$\frac{1}{4}$	0.2500	28	$\frac{7}{16}$	0.4375	0.428	0.488	$\frac{9}{32}$	$\frac{5}{64}$	$\frac{3}{32}$
$\frac{5}{16}$	0.3125	24	$\frac{1}{2}$	0.5000	0.489	0.557	$\frac{21}{64}$	$\frac{5}{64}$	$\frac{3}{32}$
$\frac{3}{8}$	0.3750	24	$\frac{9}{16}$	0.5625	0.551	0.628	$\frac{13}{32}$	$\frac{1}{8}$	$\frac{1}{8}$
$\frac{7}{16}$	0.4375	20	$\frac{5}{8}$	0.6250	0.612	0.699	$\frac{29}{64}$	$\frac{1}{8}$	$\frac{1}{8}$
$\frac{1}{2}$	0.5000	20	$\frac{3}{4}$	0.7500	0.737	0.840	$\frac{9}{16}$	$\frac{1}{8}$	$\frac{3}{16}$
$\frac{9}{16}$	0.5625	18	$\frac{7}{8}$	0.8750	0.860	0.980	$\frac{39}{64}$	$\frac{5}{32}$	$\frac{3}{16}$
$\frac{5}{8}$	0.6250	18	$\frac{15}{16}$	0.9375	0.922	1.051	$\frac{23}{32}$	$\frac{5}{32}$	$\frac{1}{4}$
$\frac{3}{4}$	0.7500	16	$1\frac{1}{8}$	1.1250	1.108	1.263	$\frac{13}{16}$	$\frac{5}{16}$	$\frac{1}{4}$
$\frac{7}{8}$	0.8750	14	$1\frac{1}{16}$	1.3125	1.293	1.474	$\frac{29}{32}$	$\frac{5}{16}$	$\frac{1}{4}$
1	1.0000	14	$1\frac{1}{2}$	1.5000	1.479	1.686	1	$\frac{5}{16}$	$\frac{1}{4}$
$1\frac{1}{8}$	1.1250	12	$1\frac{15}{16}$	1.6875	1.665	1.898	$1\frac{1}{32}$	$\frac{7}{32}$	$\frac{5}{16}$
$1\frac{1}{4}$	1.2500	12	$1\frac{7}{8}$	1.8750	1.850	2.109	$1\frac{1}{4}$	$\frac{7}{32}$	$\frac{5}{16}$
$1\frac{1}{2}$	1.5000	12	$2\frac{1}{4}$	2.2500	2.222	2.533	$1\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{8}$

All dimensions in inches.

port is based on a Subdivision report submitted by E. H. Ehrman, of the Standard Screw Co., and O. B. Zimmerman, of the International Harvester Co.

These recommendations shall apply to all finished and semi-finished bolts and screws.

## CHAMFERED POINT ADOPTED FOR BOLTS

### S.A.E. Standard for Screws, Bolts and Nuts Extended by Screw-Threads Division

The present S.A.E. Standard for Screws, Bolts and Nuts, p. C3 of the S.A.E. HANDBOOK, specifies that

The length of the effective thread of screws and bolts shall be  $1\frac{1}{2}D + \frac{1}{4}$  in. and that as bolts and screws conforming to these specifications are primarily intended for use with nuts, the oval end is not included in the nominal length.

Manufacturers of bolts and cap-screws have experienced considerable trouble owing to the lack of agreement in the industry as to the method of measuring the length of bolts and cap-screws, some users including the point in the over-all length and others not including the point, and as to the shape of the point, some users specifying an oval and others a chamfered end. The Screw-Threads Division summarized the practice of passenger-car and motor-truck builders on

- (1) The usable length of threads for bolts intended for use with nuts
- (2) The usable length of threads for cap-screws intended for use in holes tapped in cast metal
- (3) The shape of the point of bolts or screws
- (4) The over-all length of bolts or screws

Based on this summary the Screw-Threads Division submitted the following recommendation as an extension of the present S.A.E. Standard for Screws, Bolts and Nuts.

For screws and bolts using the fine screw-thread series, the usable length of the thread shall be  $1\frac{1}{2}D + \frac{1}{4}$  in. For cap-screws using the coarse screw-thread series, the usable length of thread shall be  $2D + \frac{1}{4}$  in. A supplementary report covering a schedule of thread lengths for body lengths too short to use the length of thread specified by these formulas will be submitted by the Screw-Threads Division.

The point of all finished and semi-finished bolts and cap-screws shall be chamfered 35 deg. with tolerances of plus 5 deg. and minus 0 deg., the chamfer to extend to the bottom of the thread. The corner of the chamfer shall be rounded.

The length of all bolts and cap-screws, flat head, fillister head, hexagon head, and the like—shall be measured from the largest diameter of the bearing under the head to the extreme point.

## TRANSMISSION NOMENCLATURE EXTENDED

The Transmission Division has proposed an extension of Groups 1, 2 and 3 of Division XI of the present S.A.E. Standard for Automobile Nomenclature, p. K12 of the S.A.E. HANDBOOK, covering transmission nomenclature as follows:

### PROPOSED TRANSMISSION NOMENCLATURE

Transmission main drive gear	
Transmission main drive gear bearing (front and rear if two)	
Transmission main drive gear bearing adapter	
Transmission main drive gear bearing retainer	
Transmission second and high main shaft gear	
Transmission low and reverse main shaft gear	
Transmission main shaft	
Transmission main shaft rear bearing	
Transmission main shaft rear-bearing adapter	
Transmission main shaft rear-bearing retainer	
Transmission countershaft	
Transmission countershaft gear cluster	
Transmission countershaft drive gear	
Transmission countershaft second-speed gear	If a built-up cluster
Transmission countershaft low-speed gear	
Transmission countershaft reverse gear	
Transmission reverse idler-gear	
Transmission reverse idler-gear bushing (or bearing)	
Transmission reverse idler-gear shaft	
Transmission main shaft pilot bushing (or bearing)	
Transmission countershaft front bushing (or bearing)	
Transmission countershaft front-bearing retainer	
Transmission countershaft rear bushing (or bearing)	
Transmission countershaft rear-bearing retainer	
Transmission case	
Transmission case cover (when used as cover plate)	
Control housing (when used to mount control lever or control lever and shifting mechanism)	
Control shift frame (when used to mount shifting mechanism only)	
Transmission second and high shift fork	
Transmission second and high shift rail	
Transmission low and reverse shift fork	
Transmission low and reverse shift rail	
Transmission poppet	
Transmission poppet spring	
Transmission interlock rail	

## STANDARDIZATION ACTIVITIES

The work of the Divisions and Subdivisions of the S. A. E. Standards Committee and other standards activities are reviewed herein

### INTERNATIONAL CONFERENCES

#### Several Important Projects Considered by Foreign Delegates at Meetings

At the time of the third international conference of the chairmen and secretaries of the national standardizing organizations from many of the foreign countries, that was referred to on p. 403 of the April issue of *THE JOURNAL*, a number of other visiting delegates attended conferences on screw threads, limits for fits, bolts and nuts, gears, preferred numbers, and ball bearings.

#### SCREW THREADS

The conferences on screw threads started with one between the British representatives and the Americans on April 14, at which the British Standard Whitworth threads and the American National Standard threads, their production and use, were discussed in general. The principal objective was to secure more complete interchangeability between British and American screw-thread practice, one means suggested being that the tolerance on the angle of American threads be placed on the minus side of the basic while those on the British threads be placed on the plus side, thus bringing the two series closer together by the permissible variations. Sir Richard Glazebrook, one of the British representatives, displayed a series of ring and plug gages of the British Standard Whitworth and American National Standard threads and a suggested intermediate  $57\frac{1}{2}$ -deg. international thread. At the afternoon conference, which was attended by representatives of 10 other countries, the results of the morning conference were reviewed and discussed. One of the important developments of this session was the unanimous opinion that international interchangeability of screw threads will be greatly advanced if standardized clearances can be established at the crests and roots of the British Standard Whitworth and American National threads in present practice. The final action taken by the conference was the unanimous approval of the following resolution presented by Sir Richard Glazebrook.

*Resolved* that it is desirable to make an organized inquiry into the possibility of devising a method whereby the American National Standard and British Standard Whitworth screw threads may be used indiscriminately. Such method should provide in the view of this conference for clearance at crest and roots and a good fit on the flanks. As the first step toward such a result, the suggestions<sup>1</sup> made by Mr. Sears, of British National Physical Laboratories, deserve careful consideration, and therefore the British Engineering Standards Association should be requested to submit these in some suitable form to the national committees represented at the conference and to invite their comments on them, which will be considered at some future conference.

Further, if it should appear that agreement as to the whole proposition is not likely to be secured, the conference attaches great importance to the method of standardization of the clearance at crests and roots.

#### LIMITS FOR FITS

The desirability of establishing an international standard

<sup>1</sup>These were the development of an idea in the direction that was communicated to the British in 1922, by E. H. Ehrman, chairman of the S.A.E. Screw-Threads Division.]

for the placing of limits for various classes of fits of mating parts was discussed on April 16 with the visiting delegates of the several European countries. It appeared from the discussion that the unilateral system of tolerances is practically standard in the Continental countries, but that both the unilateral and bilateral systems are used in Great Britain, with a tendency toward the former. No definite conclusions were reached, however, with regard to international consideration except that the various countries represented would continue their study of this subject. Some of the American representatives stated that their study of the systems of tolerances used in the several countries indicated that for most of the eight promulgated American standard fits a British or German standard fit that is practically the same will be found.

#### BOLTS AND NUTS

At the conference on April 16 on standardization of bolts and nuts, a forward step was taken toward the adoption of an international standard that it is contemplated will supersede standards adopted by Germany, Austria, Holland, Sweden and Switzerland following the recent war, that were based on the so-called United States Standard, with the dimensions for the wrench openings rounded to the nearest millimeter. The American representatives indicated that the United States Standard, which has been superseded in part by the S.A.E. Standard, now represents less than 3 per cent of the production in this Country, pointing to the experience of the automobile and agricultural machinery industries as confirming the soundness of the proposed new American Standard that will supersede the old United States Standard. The British delegates stated that they are conducting a series of tests which indicate that smaller nuts and bolt-heads will give satisfactory results at lower cost. The conference requested the British Engineering Standards Association to continue the experiments and submit the results to the other national bodies for consideration in connection with international standardization.

#### PREFERRED NUMBERS

Visiting delegates from Poland, Sweden, Norway, Russia, Switzerland, and Germany held an informal conference with American representatives on April 19 at which the studies that have been made of the systems of preferred numbers were discussed with notable interest. The preferred number systems, which provide for a geometric progression in sizes, dimensions, ratings, evaluations, and the like in place of an arithmetical progression, are embodied, it developed, in 100 or more standards that have been adopted principally by the Swiss, French, Austrian, and German standardizing committees. The American Engineering Standards Committee has a special committee that has been studying this subject for some time with regard to its application in American practice.

#### BALL BEARINGS

Following a meeting of the Society's Ball and Roller Bearings Division and the Ball Bearing Sectional Committee on April 20, a brief account of which appears on p. 438 of this issue of *THE JOURNAL*, representatives of the Division and Sectional Committee met on April 21 with several representatives of Sweden, Germany, Russia, Japan, and Czechoslovakia to discuss the proposal for international standard ball bearings advanced at the Zurich conferences of national standardizing bodies in 1923 and 1925. The proposals for international standards include complete ranges of sizes for radial bearings of the light, medium and heavy series and

metric thrust ball bearings. The American representatives indicated that the Zurich proposals for radial bearings have met with approval in America with regard to all nominal dimensions and practically all tolerances on diameters with the exception of a few groups of bearings in the largest sizes but that practical interchangeability is retained as between the bearings of the Zurich proposal and the revised American proposal. In the matter of width tolerances it was tentatively agreed that two tolerances be considered for all ranges of size of radial bearings as follows:

Plus zero, minus 0.005 in. for all bearings up to and including 54 mm. (2.12598 in.) wide and plus zero, minus 0.010 in. for all larger sizes.

The American Sectional Committee has approved the Zurich proposal for the radii of shaft fillets and bearing chamfers, although the S.A.E. Standard will give only the fillet radii on bearings up to and including 110-mm. (4.3307-in.) bore in the light and medium series and 90-mm. (3.5433-in.) bore for the heavy series.

Discussion of international standardization of metric thrust ball bearings indicated that the original Zurich proposal did not follow closely either European or American practice and is unacceptable to American industries. It was pointed out that in America the common practice is to use a radial type of bearings that is designed to take combined radial and thrust loads whereas European practice is largely to use a radial bearing in combination with a thrust bearing. It was also indicated that such metric thrust bearings as are used in America are made by only a few manufacturers and are based on the dimensions that originated with earlier European practice and that to make any radical changes in this Country would involve too great a sacrifice in existing tools and other expense in proportion to the volume of production. The delegate from Sweden stated that at the 1925 conference in Zurich he had been delegated to redraft the proposal for consideration by the several national standardizing bodies and these data will be placed in the hands of the Society's Ball and Roller Bearings Division, which is handling this subject for the Sectional Committee at this time.

#### CHAIRMEN AND SECRETARIES CONFERENCES

A series of seven conferences of chairmen and secretaries was held by the delegates of the 18 national standardizing bodies attending the convention of the International Electrotechnical Commission, to consider the organizing of an international standardization body. In December of last year, the Secretary of the British Engineering Standards Association, collaborating with those of the Belgian and Dutch groups, circularized among other national bodies a draft of a constitution for an international standardization body for the purpose of preparing and promulgating international industrial standards excepting those matters coming within the scope of the International Electrotechnical Commission. As a result of the conferences a proposed constitution for an International Standards Association was approved for official submission to the various national standardizing bodies through a committee of seven comprising representatives of Belgium, Czechoslovakia, Germany, Great Britain, Sweden, Switzerland, and the United States.

The proposed constitution of the Association sets forth the aims and objects as being

- (1) To lay the groundwork for international agreement upon standards by providing simple, systematic means of interchanging information on the standardization work and activities of different countries.
- (2) To develop general guiding principles for the assistance of the national standardizing bodies
- (3) To promote uniformity among the standards of the various national bodies
- (4) It is the intention of the International Standards Association that its work shall include the approval of international standards and the administrative machinery recommended is designed

so that it can be readily extended to include the approval of such international standards when sufficient experience has been acquired

The members of the International Standards Association are to be the central national standardizing bodies in the different countries, one for each country accepting the constitution. The chief executive body will be known as the Plenary Assembly composed of delegates of all the national bodies but with final authority resting with the latter. An Administrative Council having control of finances and administrative matters and advisory powers in important questions is also provided for. The method of financing the proposed Association provides that 25 per cent of the total budget as a fixed sum is to be divided equally among the national bodies, 50 per cent of the total budget is to be based on the total annual foreign trade of each country and 25 per cent of the total budget is to be based on the population of each country.

The headquarters of the Association are to be in London and as a general rule Plenary Assemblies will be convened once in 3 years on 6-months' notice, with each national standardizing body entitled to only one vote. Provision is also made for the appointment of Technical Committees to study subjects having an official status in the Association when requested to do so by one or more member bodies and upon majority vote of the members of the Administrative Council voting on the subject. The scope of the work of such Technical Committees, however, shall be clearly outlined and not exceeded.

Both the English and metric units of measure are to be used in the published recommendations of the Association unless otherwise decided in particular cases by the Administrative Council.

The countries represented at the conferences were Austria, Belgium, Canada, Czechoslovakia, Denmark, Finland, France, Germany, Great Britain, Holland, Italy, Japan, Norway, Poland, Russia, Sweden, Switzerland and the United States.

#### BALL BEARING COMMITTEES MEET

A joint meeting of the Society's Ball and Roller Bearings Division and the Sectional Committee on Ball Bearings that is sponsored by the American Society of Mechanical Engineers and this Society under the rules of procedure of the American Engineering Standards Committee was held in New York City on April 20 preparatory to meeting visiting foreign delegates on the following day who were in attendance at the Third International Standardization Conference and the convention of the International Electrotechnical Commission.

Agreement was reached regarding the dimensions and tolerances for the light, medium and heavy series of annular ball bearings proposed for American standard and to be submitted to the foreign standardizing bodies for consideration as international standard. The report of the Sectional Committee is based on the standards of the Society that have been used for many years with certain modifications that the Sectional Committee felt could reasonably be accepted by manufacturers and users to meet the proposals for international standards submitted by the other national standardizing bodies in conferences at Zurich, Switzerland, in 1923 and 1925. The tables for these bearings will be included in the report of the Sectional Committee to be published at a later date. It was decided to limit the range of the tables to be included in the revised S.A.E. Standard to bearings having bores up to and including 110 mm. (4.3307 in.) for the light and medium series and 90 mm. (3.5433 in.) for the heavy series.

The Sectional Committee approved the S.A.E. Standard for the wide or double-row type of ball bearings manufactured in America and this will be included in the Sectional Committee's report.

One of the proposals submitted at the Zurich conferences was an international standard for metric thrust ball bearings. This was referred by the Sectional Committee to the Ball and Roller Bearings Division of the Society's Standards

Committee, which has made a careful study of American practice in comparison with the existing S. A. E. Standard. The Division is to continue its study of this subject primarily to bring American practice to a common standard that can later be submitted to foreign countries for consideration in connection with formulating an international standard.

## S.A.E. HANDBOOK TO BE MAILED MAY 15

### Will Include Standards Submitted at January Meeting and Approved by Society

The recommendations submitted to the Standards Committee at the January, 1926, Annual Meeting in Detroit were submitted to a letter-ballot of the voting members of the Society in March, the ballots being returnable on March 29. The results of the letter-ballot indicate that no relatively large minority is opposed to the adoption of any of the recommendations and they will all, therefore, be included in the March, 1926, issue of the S.A.E. HANDBOOK.

This is the first issue of the S.A.E. HANDBOOK in the bound form decided upon as a result of the decision of the Council to do away with the loose-leaf form of handbook that has been used since the first standards were printed in 1911. The principal reason for the change in the form of publication is the difficulty that has been experienced by members in keeping their handbooks uptodate, it being an unwelcome task to insert new and superseding data sheets semi-annually and to check the collection of over 300 data sheets from time to time to make sure that none have been lost or inserted incorrectly. In the bound form a specification in a given issue can be definitely understood to represent the most recent action of the Society providing not more than 6 months have elapsed since the given issue was printed.

The need of authoritative information in convenient form as to the sources of supply of parts and materials fabricated according to S.A.E. Specifications has become increasingly apparent in the last few years. The financing of the bound volume by carrying a limited amount of advertising matter makes possible the issuing of such an index. It is believed it will aid in extending the use in practice of the S.A.E. Specifications. Advertising in the S.A.E. HANDBOOK is limited logically to advertisements of S.A.E. Standard parts and materials, which are defined as parts made in accordance with existing S.A.E. Specifications that determine the dimensions necessary to allow interchangeability and as materials that conform to existing S.A.E. Specifications.

Owing to the new form of publication it has been found possible to eliminate the use of handbook running heads on each page and the S.A.E. emblem. This has increased the length of the text page by 1 in. or approximately 20 per cent. Owing to the expense of making new plates for the pages in the handbook not revised at the January meeting of the Standards Committee, over 400 pages have been printed from the old electrotypes, but these pages will be revised in future issues. As the purpose of printing the handbook in the new form is to make it of more use to the members, suggestions as to any way in which the material can be printed to better advantage in future issues will be appreciated.

The complete vote on all the Standards Committee recommendations balloted upon by the Society is given in the accompanying table. The first column gives the number of affirmative votes cast; the second, the number of negative votes; and the third, the number of members who voted neither way.

#### AGRICULTURAL POWER-EQUIPMENT DIVISION

	Yes	No	Not Voting
Tractor Belt-Speeds	333	2	58
Tractor Testing Forms	333	2	58

#### BALL AND ROLLER BEARINGS DIVISION

	Yes	No	Not Voting
Ball-Bearing Numbers	361	2	30
Wide-Type Ball-Bearings	359	4	30
Ball-Bearing Corner Radii	361	2	30

#### ELECTRICAL EQUIPMENT DIVISION

Electric Equipment Nomenclature	344	0	49
Insulation Test Voltage	345	0	48
Fuse Clips	343	0	50

#### ENGINE DIVISION

Spark-Plugs	354	1	38
Engine Trunnions	352	1	40
Cone-Clutch Flywheels	352	1	40
Flywheel Housings	351	1	41
Engine Nomenclature	353	1	39

#### LIGHTING DIVISION

Screw-Type Connectors	345	0	48
Tail-Lamp Mountings	344	1	48
Lamp Glasses	344	0	49

#### PARTS AND FITTINGS DIVISION

Flexible-Discs	346	0	47
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#### PASSENGER-CAR DIVISION

Three-Speed Gearshift Positions	346	2	45
Radiator Shutters	346	2	45

#### PASSENGER-CAR BODY DIVISION

Upholstery Leather	330	1	62
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#### STORAGE-BATTERY DIVISION

Motorcoach Storage-Batteries	344	1	48
Monobloc Containers	343	1	49
Storage-Battery Instructions	344	0	49
Storage-Battery Nomenclature	344	0	49

#### TRANSMISSION DIVISION

Control-Lever Ball Handles	349	1	43
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#### TRUCK DIVISION

Motor-Truck Frames	341	1	51
Three-Joint Propeller-Shafts	341	1	51
Power Take-Off	341	0	52

The total number of ballots received was 393, which is a considerably larger number than has been received in letter-ballots of recent years.

## VEHICLE OPERATORS PLAN ACTIVITIES

### Definite Program in Their Interest Discussed and Preliminary Action Taken

A small informal meeting was held at the offices of the Society on April 16 to discuss ways and means of extending the Society's work in the interests of motorcoach and motor-truck fleet-operators that was the outgrowth of the following resolution passed at a recent meeting of the Metropolitan Section of the Society:

*Resolved* that it is the sense of the meeting that the attention of the Council be called to Mr. Sater's recommendation, and that the Council be respectfully requested to consider during the present year the factors of research, production and standardization, in their distinctive application to the operation of automotive vehicles.

It was stated that the foregoing resolution followed upon the statement in Mr. Sater's paper read at the Section meeting that

Since no uniform cost system is in general use by which operators of trucks may compare costs and performance, it is felt that the development of such a system by the Society of Automotive Engineers would meet as important a need of the operators of trucks as have many of the services rendered by the Society to the automotive industry in general.

Although this activity was started by the suggestion that the Society prepare a uniform system of accounting for motor-truck operators to have operation costs comparable, the plan was broadened to include standardization, research and national and local meetings activities in the interests of the operating branch of the automotive industry. In discussing uniform accounting, attention was called to the Classification of Accounts for Bus Operating Companies prepared by a Committee of the American Electric Railway Accountants Association and published by the American

Electric Railway Association as being an excellent report. It was felt, however, that what is wanted in this connection is a uniform classification of the several accounts entering into total operating and maintenance costs that would bear principally on mechanical features rather than on such costs as driver's wages, rents, insurance, and similar items. A number of topics were also suggested for presentation and discussion at Section and National meetings of the Society. The following Planning Committee was organized to study operating and maintenance subjects from the Society's point of view and to make definite recommendations regarding the organization and activity of a special Committee of the Society to develop this project:

F. K. Glynn, <i>Chairman</i>	American Telephone & Telegraph Co.
H. V. Middleworth	Consolidated Gas Co.
R. E. Plimpton	Bus Transportation
C. B. Veal	Manly & Veal

## RESEARCH AND TEACHING

NO serious difference of opinion exists on the importance of promoting scientific research in America. Doubts may arise as to whether it can be "promoted," in the popular sense of this term. Certainly the qualities of mind that make research fruitful cannot be manufactured to order nor can the physical equipment that money will buy be substituted for the intellectual and spiritual gifts of nature. But such doubts furnish no ground for argument against doing all that it is possible to do. Money cannot create genius, but it can give genius its tools and its opportunity. The proposals of the new National Research Endowment, announced on Feb. 1 by a board of trustees of which Secretary Hoover is chairman, and of which Prof. A. B. Lamb of Harvard is a member, will, it is hoped, receive a wide and effective support. Although the published declaration was limited to general principles, it is said that the trustees of the Endowment intend to raise a fund of \$50,000,000, and that it is a part of their plan to endow research professorships at American universities. The Milton Fund for Research at Harvard serves a similar purpose. It enables members of the faculties at Harvard to secure the time and the means of conducting research while continuing as members of an institution for higher education.

In recent years signs of a tendency to establish independent agencies for research, and thus to divorce research from teaching and from the university environment have been noticed. Such a tendency, if car-

ried far, would be a serious mistake. The university is the natural breeding-ground for scientific interests. In the long run the teachers will have to be relied upon to furnish the scholars, both in their own persons and in the pupils to whom they impart their spirit and method. To build up a new personnel for research would leave the teaching profession as over-burdened as ever, and would cut off one of the principal hopes of relief. To accentuate the division between teaching and research would be equally bad for the mere teacher and for the mere man of research. The former would lose in freedom and incentive and in the power to impart the spirit of creative inquiry. The latter would lose his contacts with the great intellectual tradition, with his colleagues in allied branches of knowledge and with students who furnish both criticism and discipleship. The university is the proper center of scholarly endeavor, where are focussed the influences of history and culture and where the achievements of maturity are renewed by the enthusiasm and forward look of youth.

As asserted in the declaration of the National Research Endowment, facilities for research are inadequate and the demands of teaching and administration in American universities are excessive. It is to be hoped that both problems will be met at the same time and that the public interest in promoting research will be directed so as to improve the lot of those whose duty it is to teach and administer.—*Harvard Alumni Bulletin*.

## TRAFFIC REMEDIES

THE problem of solving our traffic puzzles, particularly with reference to the accidents involved, has three phases. These are (a) engineering revision of our streets, (b) education of the driving and walking public and (c) enforcement of the traffic law.

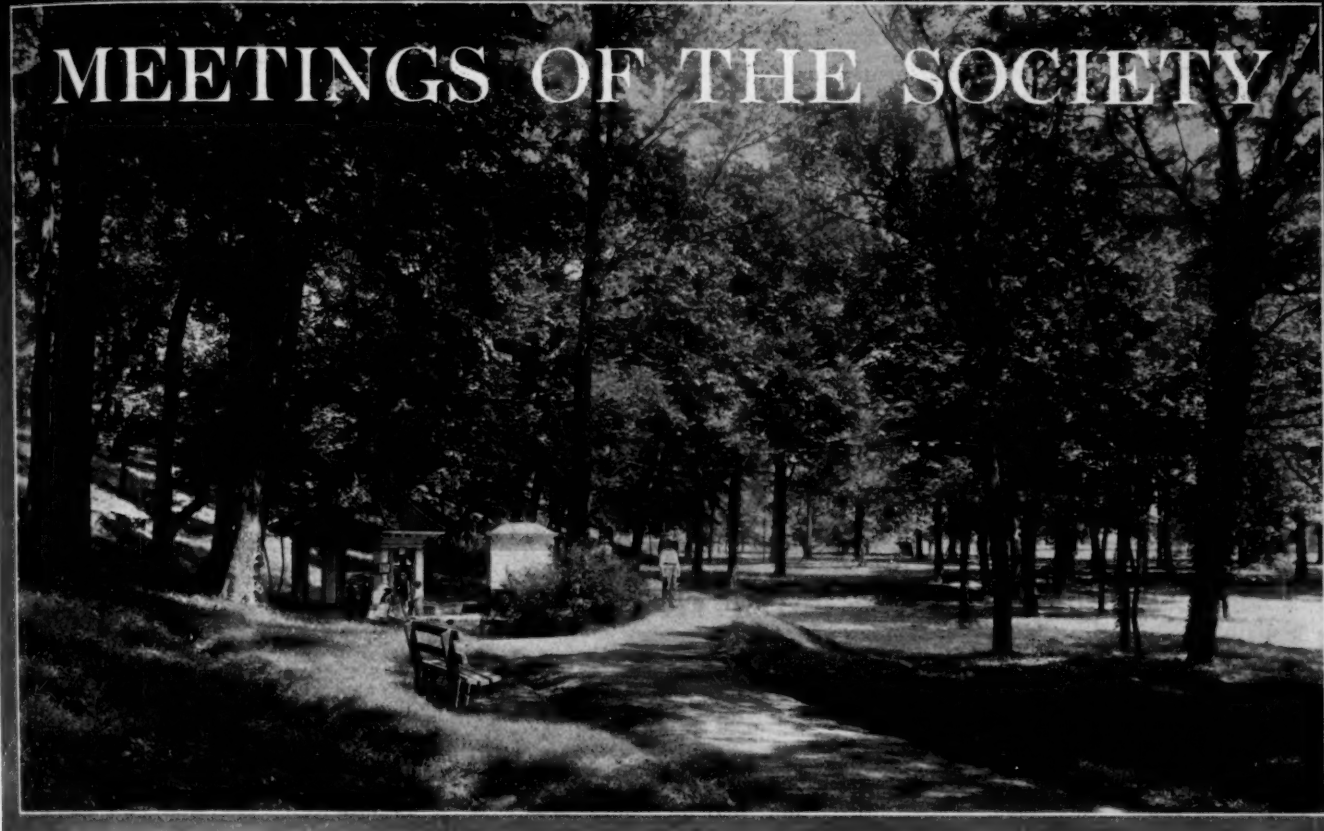
Vehicles traveling along our highways at high rates of speed imperil the lives of pedestrians who cross these streets. Investigations by city-planning experts have demonstrated that high speed of travel does not promote maximum efficiency in the use of city streets. In a chart prepared by Harold M. Lewis and Ernest P. Goodrich it is shown that the maximum number of vehicles can pass a given point in a street at about 15 m.p.h. for uninterrupted traffic and that the maximum number will pass at a running velocity of 14 m.p.h. where the traffic is controlled. Between the speeds of 10 and 20 m.p.h. the variation in street capacity is less than 5 per cent. The most efficient conditions of vehicle operation occur at speeds not exceeding 15 m.p.h. and in many cases, even lower than this.

Expediting traffic is to be accomplished, not by the operation of individual vehicles at excessive speeds, but by such means as

- (1) Using the entire street width, removing traffic and especially prohibiting parking in or near safety zones and intersections
- (2) Maintaining a high average-speed of all vehicles, including
  - (a) Keeping slow-moving vehicles off the thoroughfares
  - (b) Prohibiting cutting-in
  - (c) Keeping pavement in good condition
- (3) Minimizing delays at intersections, including
  - (a) Traffic officers or signals at all principal intersections
  - (b) Prohibiting left turns where necessary

—S. J. Williams, director, National Safety Council.

# MEETINGS OF THE SOCIETY



## SUMMER MEETING SOON!

### Indiana To Be Site of Many Big and Interesting Attractions Between May 30 and June 4

Introduced by the Indiana Section Dinner on May 30 to visiting engineers, a week of very attractive events will follow in Indiana territory. The 14th Annual International Sweepstakes will take place at Indianapolis on May 31, and the Society's Summer Meeting will convene at French Lick Springs, Ind., on the following day to continue until June 4. An invitation to attend the Indiana Section Dinner is extended to you through these columns and the details concerning this important gathering are printed on p. 444. Information, pertaining to the technical and recreational activities that are planned for the Summer Meeting, has been supplied through THE JOURNAL and through the medium of the *Meetings Bulletin*. Additional material of interest will be found in the following paragraphs and in the May 1 and May 15 issues of the *Meetings Bulletin*.

#### THE RACE SESSION

Very appropriately the Meetings Committee has arranged to include in the program of Summer Meeting technical sessions, a session that promises to be very interesting at which Fred Duesenberg and others prominent in the racing game will present informal discussions of the important engineering features involved in the cars that participate in the international classic that will be held at Indianapolis on the day before the Summer Meeting opens.

It is understood that the cars that have been entered this year will offer very many points of interest to engineers and, inasmuch as the Race Session will probably include discourses by the leading participants, there should be an unusual amount of interest in this Summer Meeting event.

#### RIDING-QUALITIES

From R. W. Brown, of the Firestone Tire & Rubber Co., and C. W. Keys, of the Gabriel Snubber Sales & Service Co.,

valuable data and ideas on riding-qualities topics will be forthcoming.

Mr. Brown, who has addressed technical sessions at former meetings, has for many months devoted his entire time to intensive research on factors involved in comfort in riding and during these studies has made numerous findings that he is ready to reveal. He will also discuss in detail matters of instrumentation, including the question of satisfactory calibration.

W. C. Keys, also well known to Society members for his practical methods of attacking technical problems, will disclose the results of an extensive investigation of the relationship that exists between riding-qualities and the construction of cushions and cushion-springs.

#### FUELS AND LUBRICATION SESSION

Speaking of cooperation, the Society's Research Committee and Department have found a large number of automobile builders helpful in carrying on an investigation of the effects of various conditions upon wear in automobile engines. Almost countless samples of used crankcase oil have formed the basis for findings that have come from the chemical analysis of these oils. Otto M. Burkhardt, manager of the Society's Research Department, will report the conclusions that have resulted from the analytical work that has been carried on very efficiently by the Bureau of Standards. Inasmuch as the samples in question have come from different parts of the Country and from various types of equipment, the results should be very valuable and of great interest.

Starting characteristics of fuels have been the subject of attention by T. S. Sligh, Jr., of the Bureau of Standards, who will present the results of his work and explain and demonstrate satisfactory methods for testing fuels.

W. A. Gruse, C. J. Livingstone, and S. P. Marley, of the Mellon Institute of Industrial Research, will present a paper, at the Fuels and Lubrication Session, on the influence of temperature, fuel and lubricant in the formation of engine carbon-deposits. Included in this report will be recent results of a comprehensive study that has been conducted at the Institute in Pittsburgh.

## THE GEAR SESSION

If you are interested in the matter of gears, you will wish to hear Arthur L. Stewart and Ernest Wildhaber, of the Gleason Works, tell about the development, production, and application of the Hypoid rear-axle gear that has recently provoked considerable interest in the automobile building fraternity.

You will also be eager to hear L. R. Buckendale, of the Timken-Detroit Axle Co., tell the engineering story of the worm-gear drive and its advantages.

## THE TIRE SESSION

In answer to a recent inquiry as to why we have heard so little about drop-center rims and tires, the Meetings Committee has obtained the consent of B. J. Lemon, of the Morgan & Wright Plant, United States Rubber Co., to present an illustrated address on this topic that will be accompanied by an elaborate exhibit and demonstration.

Thomas MacDonald, chief of the Bureau of Public Roads,

has arranged to have presented at the Tire Session an extensive report of the findings of his Bureau in the investigation of truck and tire impacts. Thousands of dollars, and many months of time, have been expended at the City of Washington to establish facts that will be of interest to tire men and automobile builders as well. The Society and the Rubber Association of America have cooperated in this investigation that has been fruitful of information heretofore unavailable. The paper will be accompanied by an interesting series of motion pictures showing precisely how a tire and truck react to the obstructions on the highway.

## ANTI-FREEZE SOLUTIONS

In response to public demand, the Bureau of Standards has given careful consideration, for a number of years, to the question of anti-freeze solutions for use in automobile cooling-systems. Certain of these solutions are corrosive, others are not effective and the whole situation has been in the past an important problem. H. K. Cummings, of the Bureau, will

## SUMMER MEETING HIGHSPOTS

## Time and Place

The Summer Meeting will be held in and about the French Lick Springs Hotel, French Lick Springs, Ind., June 1-4. Adequate hotel, sports and meeting facilities are available. Special hotel and railroad rates.

## Tuesday, June 1

*Morning.*—Registration and assignment to rooms  
Registration for sports events  
Committee sessions

*Afternoon.*—Sports events and special entertainment  
Ladies' reception  
Committee sessions

*Evening.*—Standards Committee Dinner-Meeting  
A big surprise!!!  
Semi-Annual Business Meeting  
Motion pictures  
Dancing

## Wednesday, June 2

*Morning.*—Riding-Qualities Session  
How Do Cushions and Cushion-Springs Affect Riding Qualities?—W. C. Keys, Gabriel Snubber Sales & Service Co.  
Instrumentation and Results of Riding-Qualities Tests—R. W. Brown, Firestone Tire & Rubber Co.  
Sports events and special entertainment

*Afternoon.*—Airplane demonstration and airplane-photographic exhibition  
Field day and other sports events  
Special entertainment for the ladies

*Evening.*—Headlighting Demonstrations  
Complementary-Color Headlighting Demonstration—K. D. Chambers, Light & Knowledge Press  
Testing Equipment and Methods Demonstration—Research Sub-Committee on Headlighting  
Motion pictures  
Dancing

## Thursday, June 3

*Morning.*—Race Session  
Informal talks by Fred Duesenberg and others prominent in racing, on engineering features incorporated in the cars that participated in the Indianapolis Races  
Exhibits and demonstrations

*Demonstrations.*—Indicating High-Speed Internal-Combustion Engines—H. M. Jacklin, Ohio State University. Other demonstrations of automotive equipment. In addition to these special demonstrations, practically all sessions will include a showing of specimens, equipment and apparatus. Motion pictures and stereopticon slides will also be utilized extensively.

## Afternoon.—Fuels and Lubrication Session

Some Causes of Wear and Tear in Engines—O. M. Burkhardt, research manager, Society of Automotive Engineers  
Gasoline Testing—T. S. Sligh, Jr., Bureau of Standards

The Influence of Temperature, Fuel and Lubricant in Forming Motor Carbon Deposits—W. A. Gruse, C. J. Livingstone and S. P. Marley, Mellon Institute of Industrial Research

## Evening.—Anti-Freeze Session

Possible Solutions of the Anti-Freeze Problem—H. K. Cummings, Bureau of Standards

Motion pictures

Grand Ball

Indiana Section Stunt

Chicago Section Stunt

## Friday, June 4

## Morning.—Gear Session

Design, Production and Application of the Hypoid Rear-Axle Gear—A. L. Stewart and Ernest Wildhaber, Gleason Works  
Engineering Story of the Worm-Gear Drive—L. R. Buckendale, Timken-Detroit Axle Co.

## Afternoon.—Tire Session

General Results of the Cooperative Motor-Truck Impact-Tests—J. A. Buchanan, Bureau of Public Roads, and J. W. Reid, Rubber Association of America

Drop-Center Rim and Tire Developments—B. J. Lemon, Morgan & Wright plant, United States Rubber Co.

## Evening.—Summer Meeting closes

Departure of special trains

address a session of the Summer Meeting on this topic and is expected to furnish considerable helpful information.

#### DEMONSTRATIONS AND EXHIBITS

As usual, the presentation of technical papers will be accompanied by extensive exhibits and demonstrations. In addition there will be a worthwhile demonstration of apparatus and methods for indicating high-speed internal-combustion engines by H. W. Jacklin of the Ohio State University.

Negotiations now in progress are expected to result in other demonstrations, including the showing of automobiles equipped with heavy-oil-burning two-stroke cycle engines.

#### HEADLIGHTING DEMONSTRATION

You have probably never seen a complete demonstration of the principles involved in complementary-color headlighting. The Committee has been fortunate in making arrangements for a showing of this new development by K. D. Chambers, who is said to have brought complementary-color headlighting from the experimental stages to a real practical proposition.

It is expected that the Society's Committee on Headlighting Research will have, at French Lick Springs, a number of cars equipped with headlighting apparatus that will incorporate the new ideas that have resulted from recent research.

#### DISCUSSION REQUESTED

It is planned to circulate, among those interested, advance copies or abstracts of the technical papers, and it is requested that members advise the headquarters office in case they wish to receive this material for use in preparing discussion. The Meetings Committee urges that members take advantage of this opportunity and that they add to the interest of the sessions by presenting their ideas and the results of their experience.

#### AIRPLANE PHOTOGRAPHIC EXHIBITION

Through the courtesy of Major J. F. Curry, U. S. A., commanding officer of McCook Field, the engineering division of the Air Service will provide an airplane photographic exhibition on one afternoon of the Summer Meeting. By means of a process that has been developed by the Engineering Division, a photograph of Society members, assembled on the golf course to form the initial letters of the Society, will be made and delivered by parachute within a period of several minutes.

It is urged that every member arrange to participate in this instructive and thrilling event that will be described in detail in a forthcoming issue of the *Meetings Bulletin*.

#### RECREATIONAL FEATURES

Chairman Hill, of the Meetings Committee, has appointed a number of committees that will be responsible for carrying through a very attractive program of recreational activities, including golf, tennis, field sports, archery, and other popular pastimes. There will be ample opportunity for those so inclined to participate in these features.

Many new items will be injected in the program of sports, and a large number of valuable prizes will be awarded to those who are successful in the competitive events.

#### REDUCED RAILROAD RATES

Arrangements have been made with the railroads whereby members may purchase round-trip tickets for fare-and-a-half. This privilege will be limited to members of the Society and their families. Others can effect a considerable saving by purchasing summer-tourist-rate accommodations.

Special cars and trains operating on convenient schedules will be provided for the accommodation of members coming from or through the various centers. Additional details regarding these arrangements will appear in the *Meetings Bulletin*.

It is recommended that all arrangements for transportation be made promptly upon receipt of the certificate that will

## NATIONAL MEETINGS CALENDAR

### SUMMER MEETING

French Lick Springs, Ind.—June 1-4

### AERONAUTIC MEETING

Bellevue-Stratford Hotel, Philadelphia—  
Sept. 2 and 3

### PRODUCTION MEETING AND EXPOSITION

Hotel Sherman, Chicago—Sept. 21-23

### TRANSPORTATION AND SERVICE MEETING

Copley-Plaza Hotel, Boston—Nov. 16-18

### TRACTOR MEETING

Chicago

### ANNUAL DINNER

New York City—January, 1927

### ANNUAL MEETING

Detroit—January, 1927

be mailed with the May 15 issue of the *Meetings Bulletin*. These arrangements may be made either through your local Section Secretary or directly with the railroad agent. Members are warned that, if they delay in procuring tickets and Pullman reservations, they may be disappointed, for at the time of the Summer Meeting several gatherings of national importance held in various parts of the Country will make heavy demands for railway equipment.

#### AUTOMOBILE ROUTES

From practically all centers to French Lick Springs the roads are said to be excellent and ordinarily in splendid condition. From the American Automobile Association, recommendations have been received as to the best paths to follow. These will be included in the *Meetings Bulletin*.

#### LAST BUT NOT LEAST

Every lady who attends the Summer Meeting this year will be assured of a most pleasant experience. Special provisions are being made for her entertainment, and no stone will be left unturned to make the occasion a most memorable one.

### TRANSPORTATION COMMITTEE MEETS

#### Automotive Transportation and Service Meeting Committee Lays Definite Plans



J. F. WINCHESTER

Problems of design, construction, operation, and maintenance of trucks and motorcoaches will form the basis of the Automotive Transportation and Service Meeting, to be held at the Copley-Plaza Hotel in Boston, Nov. 16, 17 and 18. Members of all societies and associations that are interested in the subjects to be discussed will be invited to attend the technical sessions and the banquet to be held on one of the evenings. Addresses by recognized experts will be included on such subjects as the coordination of motorcoach systems and railroad operation,

operation and maintenance of motor-truck and motorcoach fleets, freight handling and store-door delivery by automotive equipment, costs of operation, brake requirements of trucks and motorcoaches, maintenance tools, and engine design from the standpoint of desirable torque characteristics.

On one afternoon of the meeting, an inspection trip to the maintenance plant of the Standard Oil Co. at East Cambridge will be made.

Chairman Winchester's committee that will be responsible for this important meeting includes the following:

H. R. Cobleigh	National Automobile Chamber of Commerce
C. O. Guernsey	J. G. Brill Co.
A. W. Herrington	Consulting engineer
F. C. Horner	General Motors Corporation
F. E. H. Johnson	Noyes-Buick Co.
A. F. Masury	International Motor Co.
V. A. Nielsen	V. A. Nielsen Co.
L. H. Palmer	Fifth Avenue Coach Co.
R. E. Plimpton	Bus Transportation
A. J. Scaife	White Motor Co.
F. J. Scarr	Pennsylvania Railroad Co.
E. W. Templin	Six-Wheel Co.
G. S. Whitham	Charles Street Garage Co.

### PRODUCTION MEETING PROGRESSES

#### Chairman Rumely Soon to Announce Topics and Speakers for Chicago Meeting



V. P. RUMELY

Unusually rapid progress has been made in the development of arrangements for the Society's national Production Meeting that will be held at Hotel Sherman in Chicago, Sept. 21, 22 and 23. Speakers for a majority of the technical sessions have already been chosen, and the Committee members are actively engaged in arranging for the Stag Carnival, the principal social event of the Meeting.

Inasmuch as the exhibition of machine-tools and heat-treating equipment will be in progress in Chicago at the time of the Meeting, a large number of members

should be attracted. Sessions on conveyor systems and methods, automobile gears, machine-tools and inspection will combine with several inspection trips to make the program most worthwhile.

The Production Meeting Committee includes the following members:

V. P. Rumely, Chairman	Hudson Motor Car Co.
George Babcock	Dodge Bros.
Eugene Bouton	Chandler Motor Car Co.
W. G. Careins	Ajax Motors Co.
C. B. Durham	Buick Motor Co.
A. H. Frauenthal	Chandler Motor Car Co.
Paul Geyser	Yellow Truck & Coach Mfg. Co.
R. M. Hidey	White Motor Co.
R. R. Keith	International Harvester Co.
Joseph Lannen	Paige-Detroit Motor Car Co.
LeRoy F. Maurer	Studebaker Corporation of America
T. Milton	Electric Storage Battery Co.
P. J. Morhan	Nash Motors Co.
Louis Ruthenburg	Yellow Sleeve Valve Engine Works
P. L. Tenney	Muncie Products Division of the General Motors Corporation

### INDIANA TO ENTERTAIN VISITORS

#### Successful Dinner of Last Year to Be Repeated on Eve of Indianapolis Races

As a curtain raiser to the Summer Meeting at French Lick Springs the Indiana Section plans some elaborate entertainment features for the visiting members who stop off at Indianapolis to see the automobile races. On the evening of May 30, the night before the races, the Section will give a dinner in honor of visiting members at 7 o'clock in the main dining room of the Indianapolis Athletic Club. Only three speakers are on the program. They are, however, names to conjure with—Arthur Brisbane, C. F. Kettering and Charles M. Schwab. A somewhat similar dinner was given by the Section last year. This was a most successful and enjoyable event, every available seat being taken.

The invitation that will be sent out later to the members of the Indiana Section is reproduced on the facing page. This is the Indiana Section's cordial invitation to you. If you wish to attend this dinner write or telegraph George T. Briggs, Wheeler-Schebler Carburetor Co., Indianapolis, at once.

To assist visiting members who are to be in Indianapolis in time for the races and the dinner an entertainment com-



*The Indiana Section  
of the  
Society of Automotive Engineers*

REQUESTS YOUR PRESENCE  
AT THE INFORMAL WELCOMING DINNER TO  
VISITING S. A. E. MEMBERS  
AT THE INDIANAPOLIS ATHLETIC CLUB  
SEVEN P. M., MAY THIRTIETH  
• 1926 •

*The Night Before the 500-Mile Race*

• •

*The Speakers will be:*

MR. ARTHUR BRISBANE      MR. C. F. KETTERING  
MR. CHAS. M. SCHWAB

• •

*Please reply at your earliest convenience to*

GEO. T. BRIGGS, Chairman of Dinner Committee, care of  
The Wheeler-Schebler Carburetor Company  
Indianapolis, Indiana

*Indiana Section Committee:*

GEO. T. BRIGGS, Chairman  
F. E. MOSKOVICS  
RALPH R. TEETOR

*Entertainment Committee:*

LON R. SMITH, Chairman  
Headquarters,  
Indianapolis Athletic Club

*Tickets \$3.50 Each*

mittee in charge of Lon R. Smith will make its headquarters at the Indianapolis Athletic Club to supply information and assistance to the visitors. Plans have been tentatively made for an informal luncheon for the visiting members on the roof garden of the Indianapolis Athletic Club at noon on Sunday. The Section intends to have the main route between Indianapolis and French Lick Springs properly posted so that those motoring to the Semi-Annual Meeting will have no trouble in finding their way.

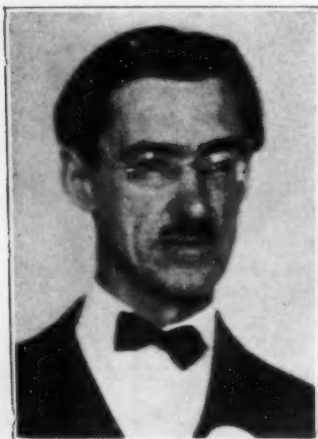
The Prest-O-Lite Co. will reserve free parking space at the races for visiting members of the Society who make application in advance. This choice parking space which adjoins the Company's plant is directly opposite the main gate of the Speedway. A hot luncheon will also be served by the Company on the day of the races to all visiting members who send in applications in advance.

If you wish to enjoy the dinner on Sunday evening, May 30, drop a line to George T. Briggs, telling him how many places you wish reserved. Applications for parking space at the races and the luncheon should be addressed to the Prest-O-Lite Co., either at Indianapolis or Speedway City.

Putting off until tomorrow what you can just as easily do today may cause you to lose out on some of those good things. Therefore, *do it now*.

## AERONAUTIC MEETING DATES SETTLED

Sept. 2 and 3 at Bellevue-Stratford Hotel, Philadelphia  
Chosen



WILLIAM B. STOUT

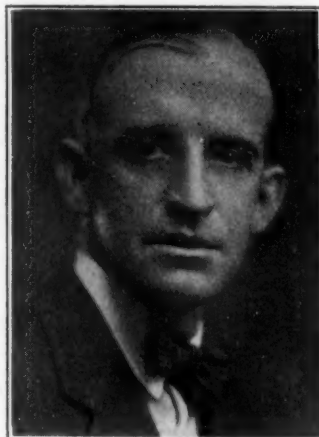
Races that will be under the sponsorship of the National Aeronautic Association.

Interesting details concerning the development of plans will be called to the attention of Society members in forthcoming issues of THE JOURNAL.

After obtaining numerous suggestions from Society members concerning topics and speakers that should be included in the Aeronautic Meeting program, Chairman W. B. Stout held a conference attended by a number of prominent aeronautical engineers at the Society's headquarters on the afternoon of April 28. The conference resulted in the formulation of concrete plans for the technical and social activities of the meeting that will be held at the Bellevue-Stratford Hotel, Philadelphia, on Sept. 2 and 3, immediately preceding the opening of the National Air

## FREEDOM FROM DIRTY WORK ACHIEVED

Due to Central-Source Chassis-Lubrication, As Told the  
Milwaukee Section



FRED H. GLEASON

Major benefits sought in chassis lubrication are surcease of annoyances experienced when using ordinary lubricating means, greater length of chassis-life, improved riding-quality and riddance of disagreeable squeaks and rattles, according to Fred H. Gleason, experimental engineer of the Bowen Products Corporation, Auburn, N. Y., who presented his paper, Chassis Lubrication, at the meeting of the Milwaukee Section that was held on April 7, in the Blatz Hotel. He described in detail a system by which all parts of a chassis are lubricated with oil under

pressure obtained from an oil-reservoir centrally located on the chassis, showed numerous lantern slides of layouts and exhibited complete working equipment and parts.

Experimental work since that of 1924 on this system was explained, and the improvements resulting therefrom were enumerated. In conclusion, Mr. Gleason said the field results show that the best lubrication is attained by use in the system of the heavier grades of engine-cylinder oils which have great viscosity, because these grades of lubricant stay in place in the bearings and prevent the entrance of water or dirt. The paper is published in full elsewhere in this issue of THE JOURNAL, and is in the nature of a progress report. About 40 members and guests attended.

As brought out in the discussion following the paper, one objection to using a chassis-lubricating system deriving its oil supply from that of the engine is rust developed in the chassis bearings due to the water that accumulates in crankcase oil; another is that crankcase oil becomes too greatly thinned to be suitable, as car operation is prolonged, metal particles and dirt also being present in it. Failure of chassis bearings is caused mainly by water and foreign matter; for that reason it is desirable to feed clean oil, as from a reservoir, and to fill the lubricating system so that oil is escaping continuously from the various outlets, in properly regulated volume, to flush-out foreign matter in the chassis bearings.

Regarding the reduction in the amount of wear in chassis bearings, Mr. Gleason cited an instance in which wear averaged from 0.008 to 0.010 in. for a car driven 53,000 miles in the last year over proving-ground roads. Use of a different grade of oil for winter chassis-lubrication from that used in summer was advocated only in case the con-

## A WARNING

APPLICATIONS FOR ACCOMMODATIONS AT THE SUMMER MEETING SHOULD BE FORWARDED  
AT ONCE!

TO AVOID DISAPPOINTMENT, MEMBERS SHOULD ARRANGE FOR TRANSPORTATION AND PULLMAN ACCOMMODATIONS TO FRENCH LICK SPRINGS IMMEDIATELY UPON RECEIPT OF THE  
CERTIFICATE MAILED WITH THE MAY 15 Meetings Bulletin.

ditions are so severe as to cause the lubricant plunger to become practically inoperative. Cost of installation of the lubricating system under discussion was stated to be from \$7 to \$50 on a production job, depending upon the amount of material required. Less than 1 qt. of oil will lubricate the chassis of an average-grade car about 1 month. Mr. Gleason believes that, when lubricating a chassis by ordinary means, more oil is spilled upon the ground than the central-source system requires for adequate lubrication.

Following a motion made by F. M. Young and seconded by C. L. Cole, it was voted that the proposed amendments to the Section Constitution and By-Laws be adopted.

## AIRPLANE SUPERCHARGER

### A. W. Gardner Gives Dayton Section a Report on Investigation with Blower Type

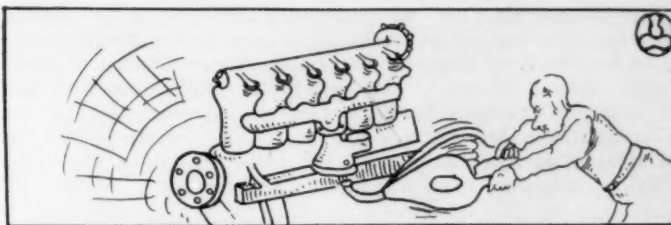
Members of the Dayton Section enjoyed the privilege, at their meeting on April 8 at the Engineers' Club of Dayton, of hearing A. W. Gardner, of the National Advisory Committee for Aeronautics, review the developments in superchargers and describe the work that has been done on the Roots-blower type for the Air Service. The address was illustrated with 16 lantern slides, showing the construction of the device, its mounting on a Liberty-12 engine and in a DeHaviland airplane, laboratory apparatus for testing its performance, and charts of its performance both in the laboratory and at altitudes up to 20,000 ft.

As the power developed by an engine is directly proportional to the weight of the charge burned in a unit of time, the power developed at altitude decreases in direct proportion with the decrease in air density encountered; thus an engine will develop somewhat less than one-half its sea-level power at an altitude of about 20,000 ft. The purpose of supercharging an aviation engine, therefore, is to maintain as nearly as possible sea-level pressure to the carburetor at all altitudes. In 1918 the importance of supercharger development was brought to the attention of the National Advisory Committee for Aeronautics by its subcommittee on powerplants for aircraft, with recommendations that the Roots-blower type be investigated. A preliminary analysis of the characteristics of this type was made by the Clark-Thomson Research, and in 1919 the engineer in charge, Mr. Lewis, made a report with complete design analyses and drawings for an experimental supercharger. One was built and sent to the Langley Field laboratory for tests, and its characteristics have been investigated both in the laboratory and during flight in several types of airplane.

#### CONSTRUCTION OF THE SUPERCHARGER

After describing the construction of the Roots-type compressor, the speaker stated that the discharge rate is not uniform and that pulsations are set-up in the discharge line and increase in magnitude with an increase in speed and compression. For use in an Air Service supercharger, it was required that this type should be a relatively high-speed small-volume machine. Tests made with a 5 x 5-in. compressor, operated at 5-lb. delivery pressure at speeds up to 1800 r.p.m., showed that the volumetric efficiency does not decrease with an increase in speed, and that the pulsations could be prevented from building up in the discharge line by using an air receiver.

The supercharger designed to be mounted directly on the rear of a Liberty-12 engine is made of light alloy castings and weighs 88 lb. The pressure pulsations are timed to come at the time the inlet-valve is open by fixing the speed of the supercharger at  $1\frac{1}{2}$  times the speed of the crankshaft. For an average engine-speed of 1600 r.p.m., the rotor speed is 2400 r.p.m. In laboratory tests the maximum over-all adiabatic efficiency of 83 per cent was obtained, and better than 65 per cent was obtained over practically the whole range of supercharger operation. The efficiency is above 70 per cent over a range of from 2 to 8 lb., which corresponds to an altitude range up to 15,700 ft.



A small booster water-radiator was found necessary when maintaining full supercharging to 20,000 ft. In the DeHaviland-4, with full supercharging to 13,000 ft. and with booster radiator, repeated climbs were made to an altitude of 20,000 ft. in 20 or 21 min.

#### ADVANTAGES OF THE ROOTS-BLOWER TYPE

In conclusion, Mr. Gardner stated that the Roots compressor would seem to be particularly well adapted for use as an airplane-engine supercharger because (a) it can be built in suitable sizes and operated at suitable speeds, (b) it has a high over-all efficiency, even in the small sizes, (c) its cost of maintenance is small and its reliability and durability are favorable, (d) it supercharges with the minimum of grief for the engine, (e) control by by-passing excess air reduces the power required to drive it at the lower altitudes, (f) use of clutches and complicated valves is avoided, (g) air is supplied to the engine at the minimum temperature at all altitudes when supercharging and at practically atmospheric temperature when not supercharging, (h) the construction is simple and the initial cost low, and (i) due to its relatively low speed, need for extreme care in balancing is obviated, friction losses are small and the gear problem is not serious.

## TWO SUBJECTS AT BOSTON MEETING

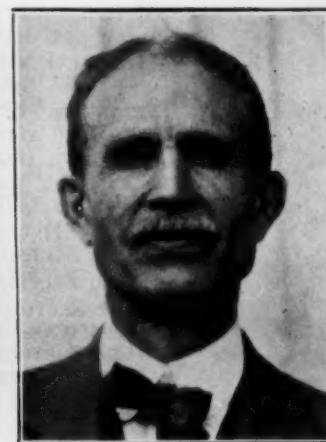
### Tire Slip and Riding-Comfort Treated by Professors Lockwood and Warner

Measurement of the slip of pneumatic and solid tires was described in an address by Prof. E. H. Lockwood, of the Sheffield Scientific School of Yale University, and factors that affect riding-comfort were discussed by Prof. E. P. Warner, of the Massachusetts Institute of Technology, at the meeting of the New England Section that was held on April 12 at the Engineers' Club in Boston. Following a members' dinner, the meeting was called to order by Chairman M. R. Wolfard and results of the election of officers for the coming year were announced by Chairman Clark, of the nominating committee, as follows: Chairman, Glenn S. Whitham; Vice-Chairmen, Frank Johnson, Dwight R. Judson and Harry Borreson; Treasurer, Albert Lodge, and Secretary, Linwood H. Young.

A motion to approve the amendments to the Sections Con-



E. P. WARNER



E. H. LOCKWOOD

stitution and By-Laws was seconded and carried. Professor Warner was elected representative and Rollin Abell, alternate for the New England Section on the committee to nominate national officers of the Society for 1927 at the Summer Meeting. Chairman Wolfard then called attention to the Transportation and Service Meeting of the Society to be held in Boston on Nov. 16, 17 and 18, and called upon the New England members to help make it a big success.

#### TIRE SLIP AND WEAR DISCUSSED

Devices for the measurement of tire slip, on which he has been working, were described by Professor Lockwood, after which there was considerable discussion of the subject by C. W. Sanderson, of the Fisk Rubber Co.; Professor Warner; Mr. Lawrence; Mr. Rice; F. E. H. Johnson, of the Noyes Buick Co.; Maurice Olley, of Rolls-Royce of America; and R. E. Northway, of the Maxim Motor Co. The discussion covered the relation of inflation-pressure to slippage, tread wear and driving radius; effect of round and flat tread profiles on wear and tendency of the steering wheels to run toward the center of crowned roads; difference in slip between front and rear wheels; increase in driving radius of the wheel and tire at speeds of 50 m.p.h. or more; bouncing of solid tires due to spring stiffness on trucks; and balancing of wheels to prevent shimmying and wearing of the tire tread into scallops.

#### CAUSES OF DISCOMFORT AND FATIGUE

In his talk on riding-comfort, Professor Warner spoke of the effects upon the passenger of vertical and longitudinal motions, their amplitude, velocity and rate of change. The difficulty of measuring their effects upon the rider and the lack of suitable instruments for the purpose were commented upon, with references to accelerometers and seismographs, which indicate and record the forces that act upon the body of the passenger.

Although rate of change of acceleration of car motions is considered to be the principal cause of discomfort, he said, no instruments for measuring this directly are available. One instrument shown in 1924 measured the total change with respect to time during a definite run. All acceleration is not unpleasant; there is definite evidence that high acceleration can be sustained without much discomfort, but if acceleration is continued over a relatively long period, even 10 sec., it may be disagreeable, as in a rolling ship. Sudden downward motion is more disagreeable than equally rapid upward acceleration, as is evident when an elevator starts downward quickly.

Comfort is what the passenger thinks he feels; it is largely mental and cannot be measured. Fatigue has different causes, can be measured by physiologists and calls for different study and treatment. One absolute essential of a car with a low axle is flexibility, said Professor Warner; the more flexible the springs, the less vibration there will be.

In the discussion, Mr. Stevens pointed out that some motion is less fatiguing than no motion; most persons like to ride close to the ground and to feel a swinging motion, and if it is not resisted it is not tiring. Mr. Olley remarked that comfort should have increased as roads were improved but it is found that good roads do not necessarily increase riding-comfort. Some years ago the statement was made that man is a walking animal, that the average frequency of vibration to which he is accustomed is 80 to 90 per min., and that therefore a frequency of not less than 60 nor more than 90 per min. is satisfactory. The best way to judge riding-comfort, he said, is to get married. One's wife does not know much about periodically of vibrations but she is sure in her mind that she can tell whether or not a car rides comfortably.

#### COOLING-SYSTEM INJECTS STEAM

##### C. H. Kenneweg Tells Buffalo Section about an Interesting New Development

Injection of superheated steam into the intake-manifold is the most novel feature of a new vapor-cooling system that was described and illustrated at the April 6 meeting of the Buffalo Section in the Statler Hotel by C. H. Kenneweg, president of the Kenneweg Motors Corporation, Pittsburgh. Advantages of this action, he said, are that it aids carburetion, overcomes the increased tendency of the engine to knock at the higher operating-temperature and practically eliminates the formation of carbon.

An average engine should operate at least 100,000 miles at a very low service cost before an extensive overhauling becomes necessary if such a combination cooling and injection system is used, declared Mr. Kenneweg, who based his assertion on experience and tests with a test car operated more than 20,000 miles in the last 18 months under all possible conditions.

##### STEAM-COOLING HISTORY, PRINCIPLES AND ADVANTAGES

Before giving the results of this test and describing the construction and operation of the system, the speaker reviewed briefly and most interestingly the history of steam-cooling,

## SCHEDULE OF SECTIONS MEETINGS

### MAY

- 5—MILWAUKEE SECTION—Maintenance With Fleet Operation—E. Wotton
- 11—PENNSYLVANIA SECTION—Problems Encountered in the Design and Construction of Universal-Joint—C. W. Spicer
- 12—DAYTON SECTION—Aerial Navigation—Bradley Jones
- NORTHERN CALIFORNIA SECTION—Aircraft Development on the Pacific Coast—Frank T. Lahm
- 14—SOUTHERN CALIFORNIA SECTION—Improvements Needed in Motor Vehicles To Render Them More Efficient, and What I Consider the Most Recent Great Improvement—F. D. Howell, Eugene Power, P. H. Decker, William H. Fairbanks, R. W. Stewart, Donald W. Douglas, and J. J. Canavan
- 17—CHICAGO SECTION—Gasoline Substitutes from Coal—A. C. Fieldner
- 18—BUFFALO SECTION—Coincidental Locks—C. B. Veal
- 20—DETROIT SECTION—Coincidental Locks—C. B. Veal
- METROPOLITAN SECTION
- INDIANA SECTION—No meeting
- WASHINGTON SECTION—No meeting

## MEETINGS OF THE SOCIETY

449

which dates back 25 years to a patent issued in 1900 to John Imbray, of England; described vividly its simple functioning and enumerated concisely the many advantages gained by steam-cooling. He said:

A steam-cooling system functions primarily by using the water-jacket exactly as a steam boiler is used in generating steam at atmospheric pressure. No cooling action occurs until the water in the engine-block reaches the boiling-point, after which the varying amount of heat generated between low-load and full-load conditions is carried in the form of steam or vapor into the condenser section and the resulting water is pumped back into the water section.

Another simple analogy was drawn to make plain the cause of crankcase-oil dilution and why it does not occur at the higher operating-temperature with steam-cooling. Breathing on a cold pane of glass and noting the condensate and then breathing on a warm pane and noting the absence of condensate illustrates the action of a cool engine and a relatively hot engine on the fuel vapor.

Major advantages of steam-cooling were summarized as the attainment by the engine of its highest thermal and mechanical efficiency within a few minutes after starting, after which an ideal operating-temperature is maintained regardless of climatic or road conditions, speed or load. The results are (a) positive elimination of crankcase-oil dilution, (b) an increase of from 20 to 25 per cent in efficiency, (c) absolute prevention of overheating or hot-spots under heavy loads, (d) lower maintenance costs, and (e) much longer engine life.

## CONSTRUCTION OF THE NEW SYSTEM

The new cooling-system is practically a combination of a straight thermosiphon system in which boiling water only is circulated rapidly through the engine-block, and a condensing system to dissipate the excess heat. The radiator-core assembly consists of a special top tank having a small steam passageway at the upper edge, but no change is made in the cooling section or in the bottom tank except that the effective cooling area can be reduced by between 25 and 35 per cent. A gear or rotary positive-action pump, preferably mounted low, and a 1/4-in. outside-diameter copper tube connecting the steam-trap with the intake-manifold through a regulating valve and necessary rubber-hose connections are required. The system operates normally under a few inches of vacuum and renders the use of a blow-off valve unnecessary. The water used for injection into the intake-manifold varies from about 1 pt. to the maximum of 1 qt. per 100 miles.

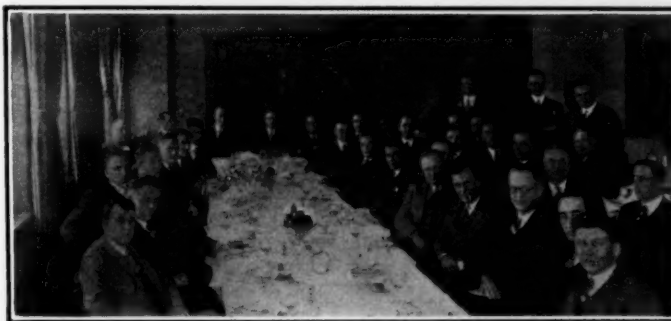
After the Model-55 Flint sport touring test car had been operated 19,745 miles, it was taken down by the Pittsburgh Flint Co. and examined. H. D. Sharkey, the president, reported by letter that the engine did not show any wear; it was impossible to take-up any of the bearings and the wear of the cylinder-walls was so slight that it could hardly be measured with the finest instrument and that the engine was in perfect condition for another 20,000 miles of operation.

Tests showed that low-grade fuels give power equal to or greater than benzol blends when the critical spark-advance and steam injection are used, and that with steam injection the critical spark-advance may reach 50 deg. or more, even with advanced throttle. Water should be added at least every 500 miles. The system cannot become air-bound, said Mr. Kenneweg, because part of the air is drawn through the vapor tube to the intake-manifold and the remaining air is circulated constantly by the pump. The area of the steam port between the water tank and the condenser is 1 sq. in. for engines up to 70 hp.

## APRIL MEETINGS IN SAN FRANCISCO

## Northern California Section Stages Monthly Meeting and Weekly Luncheons

The Northern California Section held its monthly meeting on April 15, 1926, Chairman E. C. Wood presiding. At a short business session that preceded the program, several



BREAKING BREAD AT SAN FRANCISCO  
A Monthly Meeting Is Not Enough for the Northern California Section, So Weekly Luncheons Are Also Held

matters were transacted with the utmost despatch. The proposed amendments to the Section Constitution, By-Laws and Rules, presented at the March meeting, were adopted by the Section. E. C. Wood was chosen to represent the Section on the Society's Nominating Committee during the Summer Meeting at French Lick Springs. Chairman Wood spoke of the splendid work being done by E. A. Cornely, chairman of the Section's Membership Committee, and his helpers and bespoke the cooperation of all the members of the Section in this important work.

## PROFESSOR DOMONOSKE SPEAKS

A. B. Domonoske, associate professor of experimental engineering and director of shops at the University of California, Berkeley, was introduced as the sole speaker for the meeting. Automotive work in the University of California was the topic interestingly presented by Professor Domonoske, who stated that the first automotive interest at the University appeared in the student body, when four seniors in 1907 prepared theses setting forth the results of a test on a White steam automobile. Equipment was meager and very little encouragement was given to this type of work until the war developed greater interest in automotive work. In the early years, the students were concerned with the performance of the automobile as a whole; later, particular phases were studied; and now consecutive theses are run on small units of the system.

Students of automotive engineering at the University benefit by the fact that the Headlight Testing Agency for the State of California has been located there since 1919. Its function is to test lenses, submitted by the Division of Motor Vehicles, to determine whether the technical requirements of the Motor Vehicle Act are met. Stop and other signal devices are also submitted to the Agency for operation and visibility tests. In these duties the Agency is not a legislative or enforcing branch of the Motor Vehicle Division but acts only in a testing and consulting capacity. Although the apparatus may be used for purposes of instruction, the functions of the Agency are entirely distinct from the academic work.

The testing policy of the University was defined by Professor Domonoske who stated that apparatus may be tested at the University in conformity with one of the following plans: (a) by senior students in a definite series of tests preparatory to the writing of a thesis, (b) by staff members in cases where the device is of such a nature as to offer research in a new field or where no commercial facilities exist for making the necessary tests and (c) by advanced students when the instructor assigns some commercial article as a special problem.

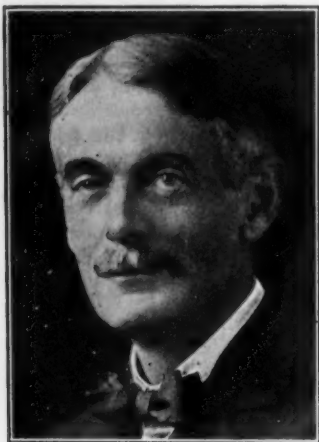
Professor Domonoske believes that the greatest need of the future in this work is the procuring of lecturers to inculcate the ideals of clear thinking and fundamental knowledge in order that the results of experiments can be correlated and developed into laws.

The Northern California Section holds weekly luncheons in addition to the regular monthly meeting. Subjects announced for discussion at the luncheon in April were as

follows: April 9, Economical Transportation, by J. Clark, of the Standard Oil Co. of California; April 16, Engineering Features of the New Chrysler, by George Campe, of George Campe, Inc.; April 23, Local Facilities for Gear Manufacture, by C. W. Gebhardt, of Echlin, Sheeline & Echlin; and April 30, Automotive Storage-Battery, by William R. Wright, of the Westinghouse Union Battery Co.

## METROPOLITAN SECTION HEARS CRANE

### Interesting Comparison of Engine Design and Operation Factors Made



H. M. CRANE

To very definite and logical reasons can be ascribed the trend in the development of automobile engines in the last 25 years, according to H. M. Crane, technical assistant to the president of the General Motors Corporation, who addressed the Metropolitan Section members at their meeting of April 21. In his very instructive and interesting address, Mr. Crane enumerated the historical steps that have brought the automobile engine from a crude, single cylinder affair through the various stages of multiple-cylinder development; he recounted the causes for the trend in this remarkable development and included in his discourse a comprehensive analysis of the design factors involved in engine evolution.

#### FROM ONE TO TWELVE

Naturally the most simple form of engine came first, to be followed as manufacturing conditions and increased knowledge warranted by the double opposed type. Then followed the three-cylinder vertical engine, the forerunner of the present six, and soon thereafter the four-cylinder vertical type made its appearance. It was some little time after the four-cylinder vertical type had become established that the free-vibration characteristic of this type combined with other factors to bring about the development of six-cylinder engines.

In 1908 E. R. Hewitt constructed an eight-cylinder V-type of engine consisting of two four-cylinder units acting at an angle of 90 deg. on a single crankshaft; this type later found general use in Europe and was finally developed in this country. Later the eight-cylinder engine was modified for automobile use by bringing the eight cylinders into line, this type having been used previously in motorboats and racing cars. Previous to this period, however, the 12-cylinder V-type engine, consisting of two six-cylinder units at 60 deg. operating on a single crankshaft, claimed a certain amount of popularity. An eight-cylinder V-type engine set at 60 deg. had also found extensive use.

#### PUBLIC DEMANDS PREVAIL

Mr. Crane stated that in his belief the motoring public in America demand excellent low-speed performance, good hill-climbing ability on high gear, excellent acceleration, and smoothness with little vibration and noise. He believed that the Packard models of 1906, 1907 and 1908 pointed the way to the performance characteristics that are now almost universal, due to public demand.

Although cars equipped with four-cylinder engines are still sold in largest quantity, the popularity of this type has decreased materially in the last few years owing to the extensive construction of improved highways upon which high-speed operation, with the minimum amount of vibration, is

sought and owing to the increased use of closed bodies that serve to emphasize the presence of vibrations that were formerly not noticed.

In a comparative way, Mr. Crane explained, by the use of charts, the natural characteristics and design factors involved in the construction of engines of one, two, three, four, six, eight, and nine cylinders. In these comparisons it was assumed that cast-iron pistons and steel connecting-rods were used, the bore-stroke ratio was approximately the same in all cases and the pistons were consistently of the long-trunk type with the skirt length approximately equal to the bore. In the computation of bearing loads due to moving forces, a rotative speed of 2500 r.p.m. was chosen. A unit load of 300 lb. per sq. in. for the explosion forces was assumed. The valves were proportioned approximately the same in all cases.

By means of the charts, Mr. Crane demonstrated the distribution of loads upon the various bearings. Maximum explosion pressures and maximum dynamic pressures at each point were shown in a comparative way.

#### LUBRICATION AND QUIETNESS

In speaking with especial reference to quietness of operation, Mr. Crane very strongly advocated the use of bearings that are ample in number and size and the positive distribution of a generous supply of oil to all moving parts.

Also, with reference to quietness, the use of large wrist-pins and long skirted pistons was recommended. The speaker also discussed the importance of having the valves seat squarely. In this connection he described in detail a cam-contour that was said to be satisfactory from the point of view of quiet valve functioning. Mr. Crane believed that the possible difficulties of adjustment would render impracticable the use of proposed cams that produced zero velocity at the time of picking-up the valve. It was stated that the greatest amount of valve noise is produced as the valves seat.

At the conclusion of the very helpful discussion that followed Mr. Crane's address, the speaker stated his firm conviction that great advantages are offered by using a comparatively slow-running engine for a given car-speed, under which conditions it is possible to utilize to drive the car a greater percentage of the power developed, less of the power being wasted in pumping losses.

Mr. Crane also stated that, in his opinion, there is no great demand on the part of the public for fuel economy. At such time as this becomes an important consideration it will be most easily attained by changes in gear-ratio; a 20-per cent variation in gear-ratio was said to offer a fuel saving of nearly 20 per cent.

Preceding Mr. Crane's presentation, Chairman MacCoull announced that the tellers for the election of Section officers for the coming year wished to report a unanimous vote for the following ticket: F. K. Glynn, chairman; C. B. Veal, vice-chairman; H. M. Rugg, secretary, and E. F. Lowe, treasurer. Neil MacCoull was chosen to represent the Section on the Nominating Committee for officers of the parent Society; A. F. Masury was named as alternate.

## WORM GEARING FOR FINAL DRIVE

### Indiana Section Studies the Whys and Wherefores of Worms and Their Kindred

A triple play for the latest data on worm-driven axles was staged by the Indiana Section at its meeting that was held on April 8 at the Hotel Severin, Indianapolis, noted engineers from three States having been enticed into spilling the most recent facts relating to the subject for the benefit of the Hoosier automotive engineers and service men. About 110 members and guests were present. Three papers were delivered and several members prominent in the automotive industry contributed brief addresses.

Regarding the prepared papers, one on Suitability of Worm Gearing was presented by George H. Acker, chief engineer

of the Cleveland Worm & Gear Co., Cleveland; Adaptation of Worm Gearing to Passenger Cars was treated by Ray L. Buckendale, chief engineer of the Timken-Detroit Axle Co., Detroit; and Worm Gears and Worm-Gear Axles was the subject chosen by C. H. Calkins, chief engineer of the Baush Machine Tool Co., Springfield, Mass.

Among the other interesting and informative features of Mr. Acker's paper it was brought out that the worm gear is, after all, very similar in action to any sliding, or journal, bearing. A certain amount of involute rolling-action takes place in the action of the gearing, the magnitude of which increases with the gear-ratio; but the primary action is one of sliding of the worm threads across the gear teeth. Simple as this fact is, the prejudice fostered by many people against worm gears can be traced to lack of appreciation of it. Due to the nature of the surfaces in contact, the best obtainable bearing takes the form of a narrow strip running across the gear tooth, and the bearing pressures obtained are high. Therefore, it is indicated clearly that the most favorable bearing-conditions should be maintained. He said further that, under automotive conditions, the limit of load for worm gearing appears to be set by the fatigue limits of the bronze and that therefore we look to the nickel-bronze, with its increased ductility and length of fatigue life, to increase the capacity of worm gearing. Experiments to prove or disprove this possibility are in progress.

#### WORM DRIVE FOR PASSENGER CARS

Application of the worm-gear drive to the high-grade passenger-automobile as soon as its virtues become more widely known was predicted by Mr. Buckendale. His paper compared the worm-gear type with other types of final drive and he summarized his main reasons for his prediction by saying that the worm gear allows the lowest possible center of gravity of the vehicle, is inherently a silent gearing and has the greatest probable length of life during which the silence is maintained. Its disadvantages are mainly that its cost is slightly greater than that of other types and that it requires an entirely different type of axle and therefore cannot be applied to axles in production at present merely by changing the carrier.

#### DETAILS OF WORM GEARS

Subsequent to a brief historical review of the development of worm gears, Mr. Calkins dealt with worms and worm wheels in detail, presenting the subjects of proper choice of materials, tooth shapes, worm-gear efficiency, the stresses imposed on worm gearing and worm-gear axles. Usually, he said, the worm is made of case-hardened steel of S.A.E. No. 1020 grade; however, when the worm diameter is smaller and the stresses are greater, nickel steels such as S.A.E. Nos. 2315 and 2320 grades are utilized. The worm should be properly heat-treated and carbonized to produce a glass-hard surface. Grinding of the worm thread is necessary to remove distortions. Bronze is the only material of which Mr. Calkins knows that will enable the worm wheel to withstand the high stresses imposed by motor-vehicle axles, and three typical bronze alloys are in common use. The degree of hardness of the bronze is very important. Duralumin, forged and heat-treated and used for worm gears, costs approximately the same as bronze and reduces the weight two-thirds; such worm wheels have withstood severe service.

As to tooth shape, the common pressure-angle is 30 deg. This angle produces an included axial angle of 60 deg. and a normal included angle of 40 or 50 deg., depending upon the lead, and also secures proper reversibility. A properly made worm gear is as efficient as any other form of gearing, according to Mr. Calkins, and he mentioned efficiencies of from 97 to 99 per cent attained by hour-glass shaped worm-gears under ideal loads and conditions. Tooth pressures and rubbing velocities are the two important considerations affecting stresses on worm gears; the stresses vary with the lead angle. In conclusion, he stated that if a worm-gear axle is unsuccessful, this is due to imperfections of design and manufacture and not because the principle of the worm drive is not practicable.

In the discussion which followed the papers, W. G. Wall emphasized the desirability of worm drive due to its silent operation as compared with other gearing, saying also that it seems to have a tendency to soften or deaden other vibratory noises from the driveshaft and the transmission. C. S. Crawford described tests made on a heavy passenger-car, alternately using worm gearing and bevel gearing for the final drive. As these tests continued, he said, the worm gearing became more satisfactory and the bevel gearing gave less satisfaction. F. S. Duesenberg described some of his experiments with final-drive gearing suited to high-speed cars.

The following Section officers were elected at this meeting for the coming year: Ralph R. Teetor, chairman; George T. Briggs, vice-chairman; Charles A. Trask, treasurer; and Raymond F. Buckley, secretary.

### TRAINING OPPORTUNITIES NEGLECTED

#### Younger Tells Cleveland Section Automotive Industry Is Weak in This Respect

I often marvel at the automotive industry. It is the largest industry in the Country and its products include all means of individual transportation. The airplane, the automobile, the motor truck, the motor-coach and the tractor are all products of its skill. It uses practically every material, metallic and non-metallic. It makes use of all the forces known to man, and employs the sciences of chemistry, physics, metallurgy and thermodynamics to further the successful development of its products. Yet, in the field of training personnel, it is weak. We have not yet solved all of our problems, by any manner of means; and these problems are becoming more complex and more scientific as time goes on. Problems of the future will require a high degree of intelligence for their solution, and this intelligence must be trained. Manufacturers in the automotive field should take action to assure that the early training of young men who will later enter the industry will give them the necessary fundamentals for their promotion with reasonable rapidity.

Thus John Younger, professor of industrial engineering at Ohio State University, and editor of *Automotive Abstracts*, tersely summarized his conception of the present situation in the automotive industry, as he spoke on Training of Future Executives at the April 19 meeting of the Cleveland Section.

#### UNTRAINED INTELLIGENCE SUFFERS HANDICAP

Recalling the words of an old teacher, Professor Younger stated that a college training fits a man to learn a thing in less time than the boss requires to learn of the man's initial ignorance. In other words, the college and university



T. V. BUCKWALTER



JOHN YOUNGER

should teach students how to learn. At the completion of this education, the students' trained intelligence permits them to advance more rapidly than would otherwise be possible and to grasp more quickly the facts and important considerations by which they are confronted in assuming practical duties in connection with industry. It is often advisable, said Professor Younger, to supplement the university course with a modified apprenticeship course of, say, one year at most, during which time the graduate will become adjusted to the industrial conditions in which he will work during his career.

#### RESULTS OF TRAINING

Citing the field of electric transportation as one most nearly similar to the automotive field, the speaker cited that from a group of 1066 executive officers 580 were college graduates, 357 of these coming from schools of engineering and 223 from academic and law courses. In this major group 151 presidents were numbered, 92 of them being college trained and, of these, 45 per cent came from academic colleges and 37 per cent from engineering colleges. Among vice-presidents 67, in a total of 122, had college training. Of these the engineering graduates, with a total of 40, outnumbered the academic graduates by 13. Of 215 general and local managers, 126 had college degrees, nearly two-thirds of this group being engineers. The highest percentage of men with higher education is in the engineering group, 80 per cent of the 31 chief engineers being college graduates.

Professor Younger called attention to the fact that the three largest electric companies, the General Electric, the Westinghouse Electric & Mfg., and the American Telephone & Telegraph, train only college graduates for executive positions. An outline of the methods, by which industrial organizations cooperate with educational institutions, was given.

Inasmuch as Professor Younger's paper is printed in this issue of THE JOURNAL, no further details will be presented in this news account.

A report from the Cleveland Section states that the April 19 meeting was held at the Cleveland Hotel with an attendance of over 150 members and guests. A dinner and entertainment preceded the meeting. Chairman John Jaschka presented the new Chairman, T. V. Buckwalter, who presided over the meeting. The discussion was said to be one of the best that has been recorded this year.

#### CHICAGOANS HEAR ABOUT RAIL CARS

##### Scarratt Gives Fine Paper on Design—Section Officers and Delegates Elected

Motorized rail-cars were described in a most informative paper delivered by A. W. Scarratt, mechanical engineer of the Minneapolis Steel & Machinery Co., at the April 23



O. W. YOUNG



A. W. SCARRATT

meeting of the Chicago Section in the auditorium of the Western Society of Engineers, following the usual members' monthly supper. The paper discussed rail-car design and construction in detail, with especial consideration of the engine, transmission, driving trucks, and cooling-system. Special designs required for the various units were shown.

The meeting was well attended, with 47 members at the supper. Discussion of the paper was limited because of lack of time before adjournment.

A business session was held before delivery of the paper. Officers elected for the coming year were: Chairman, Otto W. Young, assistant sales manager, Hyatt Roller Bearing Co.; Vice-Chairman, W. J. Buettner, secretary-treasurer, Bendix Corporation; Secretary, F. G. Whittington, chief engineer, Stewart-Warner Speedometer Co.; and Treasurer, J. W. Tierney, sales manager, Electric Storage Battery Co.

Taliaferro Milton, branch manager, Electric Storage Battery Co., was elected a member of the Sections Committee of the Society; and O. B. Zimmerman, experimental engineering department, International Harvester Co., was elected a member of the Nominating Committee for the national officers of the Society at the Summer Meeting, with D. P. Barnard, 4th, research engineer, Standard Oil Co. of Indiana, as alternate.

Approval of the proposed amendment to the Section Constitution, By-Laws and Rules was voted, with an amendment providing that the fiscal year start on June 1 instead of May 1, so that the last meeting of the fiscal year shall be held under the retiring officers of the Section.

#### OIL FILTERING DEVICES

##### Southern Californians Have Lively Discussion Following Interesting Talk

A dinner, a talk, a discussion, and a demonstration were the elements that combined to make the monthly meeting of the Southern California Section, held on April 9, an enjoyable occasion for the 70 members and guests who were present. The meeting took place at the Los Angeles City Club with Secretary Favary acting as chairman.

At a short business session, preceding the program, the proposed amendments to the Section Constitution, By-Laws and Rules that had been presented at the March meeting, received the approval of the Section. Mr. Favary at that time brought up the necessity for electing a representative to serve on the Society's Nominating Committee that will function at the Summer Meeting and stated that this matter will receive attention at the May meeting of the Section.

Announcing the subject of the program as Oil-Filtering Devices, Mr. Favary led up to a discussion of the topic by some interesting preliminary remarks in which he outlined briefly the reasons for difficulties experienced today with lubrication which were not encountered formerly. These difficulties he attributed to crankcase-oil dilution, resulting from the use of present-day gasoline having heavier ends and vaporizing less readily than was the case sometime ago; because of the dilution of the crankcase oil, the oil-film becomes too thin to protect the engine from the particles of abrasive material that are suspended in the oil, and the need for a device to remove either the dilution or the abrasives becomes apparent.

##### W. W. MACDONALD THE PRINCIPAL SPEAKER

W. W. MacDonald, of the W. W. MacDonald Co., San Francisco, was then introduced as the speaker of the evening, with the remark that he would discuss the harm done by inadequate lubrication and would describe a way to obtain better lubrication. Mr. MacDonald warned against the idea of looking upon an oil-filtering device as merely another accessory; it is, in his opinion, a necessity. Stating that with proper lubrication no wear takes place, the speaker told about an automobile that had run more than 150,000 miles without receiving any repairs except that after 100,000 miles the

valves had been ground; after each 100 miles the crankcase was drained and the viscosity of the lubricating oil was built-up to its original point. Mr. MacDonald traced in some detail the growth of the dilution problem and mentioned several types of oil-filtering device useful in preventing ill results from improper lubrication. An oil-filtering device, he said, is more efficacious than frequent drainage of the crankcase in securing lubrication, because investigation has shown that in the average draining of the crankcase less than 50 per cent of the solid matter is removed.

#### FILTER NOT INTENDED TO SAVE OIL

The point was stressed that an oil-filtering device is not offered to the public to save oil but to make the oil render maximum service. The speaker described the filter manufactured by the company that he represents, which operates on the principle of heating a certain quantity of oil continuously and abstracting therefrom the oil and gasoline vapors. He mentioned as one of the advantages of his device the fact that it is not part of the lubricating system and therefore does not interfere with the oil-pump or any part of the distributing system. The description included some remarks about cleaning the filter, which should be washed in kerosene rather than gasoline, because gasoline shortens the life of the filter cloth; the cleaning, which requires about 7 min., should be done every 1000 miles in the case of engines that have been operated prior to the installation of the device, although in cars that are fitted with the device from the beginning of their service cleaning need not take place under 2000 miles, unless the car is used for short runs as in delivery service.

#### LIVELY DISCUSSION AFTER TALK

At the close of Mr. MacDonald's talk, a number of other speakers, representing manufacturers of various oil-filtering devices, described their respective products. The descriptions and the ensuing discussion served to amplify the statement of one speaker to the effect that two chief divisions of opinion regarding the devices for improving lubrication are that (a) the elimination of dilution is the chief problem and (b) if the dirt is removed from oil, the question of dilution is negligible because thin oil is a better lubricant than heavy oil, provided that abrasive matter is not present.

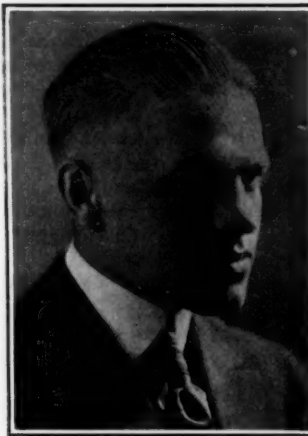
Devices other than the one that was the subject of Mr. MacDonald's talk were described by George S. Wilson, of the Pacific Auto Service; J. F. Dixon, of the Zenith Carburetor Co.; R. G. Ruggles, of the Fageol Motors Co.; and C. E. Hart who developed the Hall & Winslow Purifier. A lively general discussion followed the presentation of the material mentioned above, and at the close of the meeting the members and guests had an opportunity to examine the devices that had been described and to see Mr. MacDonald's filter in operation.

### FRONT-END-DRIVE SYMPOSIUM

#### Pennsylvania Section Told of Latest Types of Gearing Methods and Materials

Varied means of driving the front-end mechanisms of a motor vehicle and for banishing gear noises were enumerated and described in detail at the meeting of the Pennsylvania Section that was held on April 13, following a dinner at Kugler's restaurant, Philadelphia, that lured 40 members and guests to partake of it, noiselessly, of course. At the technical session the merits and demerits of chain drive, gear drive, gears made of composition material other than metal, and metal gears having teeth specially designed to minimize noise, were threshed out; a spirited discussion followed the three papers that were presented.

According to E. F. Behning of the Diamond State Fibre Co., Bridgeport, Pa., who presented a paper on the Development of the Silent Timing-Gear, gear clatter and clash caused by metal-to-metal contact develops into an annoying whir or howl at high gear-speeds, and a material was



E. H. BEHNING

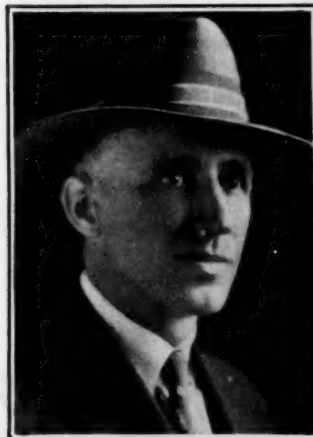


R. S. DRUMMOND

sought that is flexible and resilient enough to absorb the vibrations or change their frequency to a pitch inaudible to the average human ear. Since vibrations in the crank, the cam and the generator shafts are transmitted to the timing-gears, which run at high speeds, a material was needed that would silence the consequent noise and provide a noiseless timing-gear train. A great variety of materials was investigated and the development of laminated, phenolic, condensation products resulted; these have proved mainly suitable for timing-gear-blank stock and stock for other gears such as those suitable for crankshafts and generator shafts. A further development was that of the flexible-web cam-gear made of the composite material.

The product described by Mr. Behning is made by bonding together in laminated form various bases such as paper, linen, canvas, or sheet asbestos, depending upon the grade that is to be produced, with a synthetic, phenolic, condensation resin. This resin can be hardened, made insoluble, infusible, and chemically inert to a high degree by the application of heat. Therefore, when once so hardened, it cannot afterward be softened or dissolved. Canvas-base material is the grade used in the manufacture of timing-gears, and the paper was confined to it. The other grades of the product are made in much the same manner except that other materials such as linen and paper are substituted for the canvas.

Gears made of the composite material will, it is claimed, obviate unsatisfactory service and noise; they admit of quantity production, reduce expensive gear-downs on the production line to the minimum and assure silent, positive operation after a car is in service. Such gears can be machined with the same equipment that is ordinarily used for machining metal gears, a high peripheral speed and a coarse feed being used to obtain the best results. The peripheral speed should be about 250 ft. per min. and the



F. M. HAWLEY



C. O. GUERNSEY

lateral feed about 0.025 in. per revolution, plenty of clearance being given to the cutting tool. Ordinary, standard hobs are used for hobbing these gears; the highest possible peripheral speed should be used, with a feed of 0.075 to 0.100 in. per revolution.

An analysis of gear noises and their cause and surcease from such noises accomplished by a special design of gear tooth that he described were features of the paper on Front-End Geared-Drives that was presented by R. S. Drummond, of the Gear Grinding & Machine Co., Detroit. He covered particularly the spur-type ground-gears made by his company for various purposes and gears having great depth. He advocated this sort of gearing for timing drives on heavy-duty vehicles such as motorcoaches, motor trucks and motor rail-cars.

#### CHAINS FOR FRONT-END DRIVE

Toothed and friction gearing were said by F. M. Hawley, of the Morse Chain Co., Ithaca, N. Y., to be the two distinct classes of power transmission between two shafts, and the silent chain he described is in the toothed-gearing class according to his statement, since it has a fixed speed-ratio and causes a bearing pressure that varies almost directly with the power transmitted. He argued that, because of its elasticity and the peculiar method of contact with the teeth of the sprocket, the silent chain constitutes a medium that absorbs shocks and variations in angular velocity, and has a bearing action similar to that of a belt. The improved silent chain is made of stamped, arch-shaped link-plates assembled in alternate succession and joined by pins that act as bearings. The spacing of the pins forms the "pitch" of the chain. When assembled, the chain can be considered a flexible gear or rack. The projecting teeth of the link-plates engage the sprocket wheels over a considerable arc of the periphery of each and reduce the pressure per tooth, thus minimizing tooth-wear.

Mr. Hawley also illustrated and gave descriptions of the rocker-joint, the pin-type joint and the constant-pressure-angle chain, showing in addition a typical layout employing the triangular and other types of drive. In conclusion, he said that all engineering requires compromises in the design of parts and that this is true also regarding silent-chain drives. The object of their use is silence and satisfactory length of life, both of which are controlled mainly by design; hence, great care should govern the design. The successful drives are those that have been developed after careful consideration of the advantages to be gained and the pitfalls to be avoided.

The proposed amendments to the Section Constitution, By-Laws and Rules were adopted by the Section members. At the May 11 meeting of the Pennsylvania Section, it is expected that C. W. Spicer, of the Spicer Mfg. Corporation, South Plainfield, N. J., will read a paper entitled Universal Joints and Propeller-Shafts, treating this subject from an engineering viewpoint.

#### WASHINGTON SECTION HEARS LEAMON

##### Speaker Believes That Vapor-Phase Cracking Will Be the Process of the Future

An enthusiastic audience of about 30 members and guests attended the meeting of the Washington Section, held at the Cosmos Club in the City of Washington on April 23, where William G. Leamon, consulting chemist and engineer, delivered a most interesting talk on the Vapor-Phase Phase of the Anti-Knock Problem.

Referring to the fact that the cracking operations which have become of commercial importance up to the present

have been justified and their right to exist has been measured in terms of the quantity demand for motor fuel, Mr. Leamon asserted that the latest and wisest demand is for quality, commonly thought of in terms of "anti-knock" characteristics. He spoke briefly of the liquid-phase processes wherein the oils of large molecules are heated under conditions whereby these molecules in liquid phase are shattered or broken up into similar molecules and stated his opinion that the cracking process of the future will be the vapor-phase method, in which the demolishing operations will be carried on with molecules in vapor rather than in liquid phase. He supported his belief by a discussion of the vapor-phase process, in which his remarks tended to show that the product of this process is superior to that of the liquid phase in anti-knock properties.

#### AN INTERESTING SERIES OF SLIDES

After asking his hearers to achieve an open-minded attitude by forgetting what they already knew about oil chemistry and petroleum refining, Mr. Leamon took them briefly and entertainingly through an interesting course in both subjects by showing 18 lantern slides accompanied by appropriate comments and explanations. The earlier slides in the series were concerned with the molecular structure of different families of oil, and the later slides attempted to give a bird's-eye view of the motor-fuel problem from the refiner's position. For example, one slide represented what might be produced from the same average crude-oil by two different refining plants; another depicted schematically what happens when a petroleum oil is subjected to thermal decomposition; a third enumerated the elements of a cracking system, namely, heating, reacting, economizing, and selecting; and still other slides, indicating how these elements are combined in certain processes, included diagrams and photographs representing the process in which the author is especially interested. Speaking of the product evolved from that process, from the viewpoint of anti-knock characteristics, Mr. Leamon said that it may be considered as equivalent to an ordinary gasoline-benzol blend containing 35 per cent of benzol.

#### WHAT ABOUT THE FUTURE?

In expressing his conception of the reason for and the future of anti-knock fuels, Mr. Leamon deprecated the idea that greatly-increased economy and efficiency would result from a higher compression-ratio. The present automobile engine is, he believes, already over-compressed to a point where the fuels that are being developed will do well to meet present engine requirements. He stressed the need for the development of anti-knock fuels, stating that the average automobile of today will show an increase in mileage of 20 per cent when supplied with a fuel of adequate anti-knock properties. Contrary to the statement of some geologists, Mr. Leamon expressed the opinion that, for a number of generations, oil would remain virtually the sole source of automotive fuel.

The lively discussion that followed the presentation of this paper dealt with such questions as the anti-knock qualities of Mr. Leamon's product as compared with benzol and tetraethyl-lead blends, gumming tendencies, the cost of production, and the like.

#### RESULTS OF ELECTION

At a brief business session, the following officers were elected to guide the Washington Section through 1926-27: Chairman, R. F. Kohr; Vice-Chairman, Conrad H. Young; Secretary, J. O. Eisinger; and Treasurer, George E. Reynolds. A. W. Herrington was chosen to serve on the Society's Nominating Committee, with Dr. H. C. Dickinson as alternate.



# Amphibian-Airplane Development

By GROVER C. LOENING<sup>1</sup>

ANNUAL MEETING PAPER

Illustrated with PHOTOGRAPHS AND DRAWINGS

## ABSTRACT

**L**IMITATION of landing conditions due to having seaplanes that are unfit for use over land and land airplanes that are totally unfit and dangerous over water is an almost insurmountable barrier that has delayed the progress of commercial aviation, since an airplane not capable of landing anywhere and starting anywhere fails in an essential fundamental that is required of a vehicle suited for universal usage. The aeronautic problem presented is therefore a major one that demands an amphibious type of machine capable of operating over land or over water with equal facility, and it is the development of an airplane of such type that the author describes.

Historical precedents for some of the main features of the present amphibian airplane are reviewed, and the inventions, devices and procedure that have accompanied its development are stated. The disadvantages of previous types of amphibian development are analyzed, and the reasons for the advantages claimed for the new type are enumerated, together with the possible and the probable uses to which an amphibious airplane is suited, including a discussion of its future commercially.

In conclusion, it is said that, having endowed the amphibious type of airplane with proper flying qualities, with safe construction and with accessibility for maintenance and for load carrying, the term "amphibian" may eventually disappear because all efficient commercial types of airplane will have become amphibious as a matter of course.

**O**NE of the major problems confronting the aeronautical engineer and demanding solution is the removal from the airplane in a practical way of the limitation of landing conditions due to having seaplanes that are unfit for use over land and land airplanes that are totally unfit and dangerous for use over water. Spreading like an ocean over every locality as it does, the air is claimed by many to be the great future highway for quick transport and yet, after 20 years of intensive airplane-development, we are only now beginning to realize the full significance of the development of amphibious airplanes. Until we endow the airplane with the facility of landing and of starting anywhere, we limit and restrict it at the start and fail to provide it with its most essential fundamental as a vehicle suited for universal usage.

The delay or lag in the development of amphibious airplanes a few years ago was due to the simple fact that the general trend of development had been the obvious one of adding wheels to a flying boat or floats to a land airplane, the net result being that no improvement was made to either and complication, head resistance and weight were added. Therefore, to the critical air-pilot who finally had the say regarding what types achieved success, the amphibious airplane had come to mean a heavy cumbersome "crate" and, in almost every case, for years, its development had meant merely that a good seaplane was spoiled by trying to add wheels to it, or a good land airplane was made more cumbersome by



FIG. 1—AN EARLY AMPHIBIOUS TYPE OF AIRPLANE  
Wilbur Wright Flying at New York City in October, 1909, with a Canoe Fastened to His Land-Type Airplane

trying to make it over so that it would float. The development of the Loening Amphibian started, therefore, with perhaps the first definite recognition that to make amphibious airplanes successful required the initial design of a totally new type of airplane, amphibious in its very inception and complete in proper characteristics for land or for water operation from the very start. That we have apparently succeeded in building a fundamental

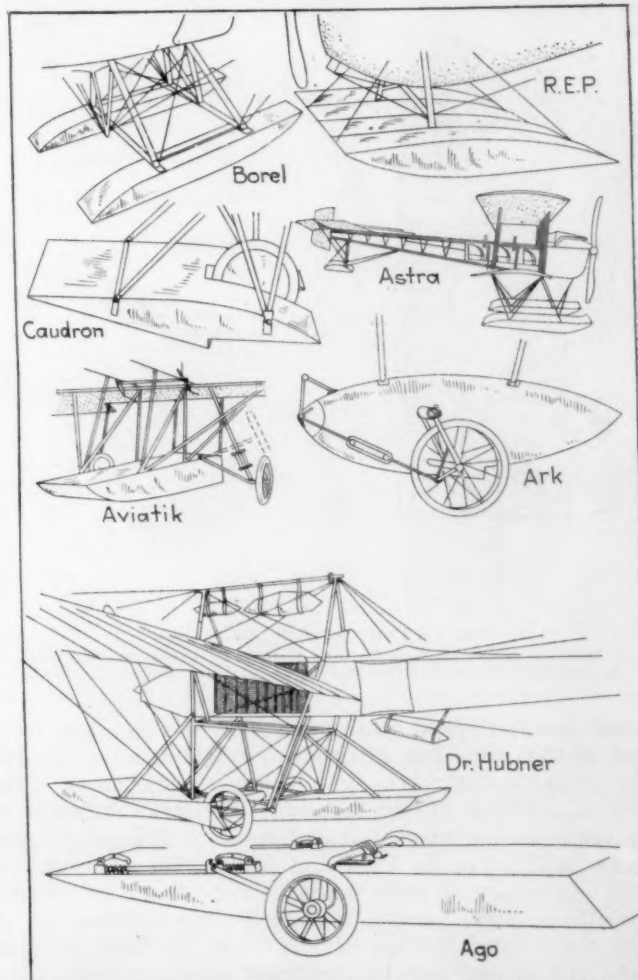


FIG. 2—EARLY EUROPEAN AMPHIBIOUS TYPES  
Several Examples of Amphibious-Airplane Development Existing in Europe in 1911 and 1912 Are Illustrated

<sup>1</sup> M.S.A.E.—President, Loening Aeronautical Engineering Corporation, New York City.

type of airplane that has reopened the entire field of use of amphibians probably is due to recognizing this necessity. The air pilot has been pleased simply because nothing has been sacrificed in performance or handling and, fortunately, in this new type, a strictly land type of airplane has been obtained which has exceptional qualities of its own, were it never to see the water, and a desirable tractor-type of flying boat long sought after and full of seaplane advantages has been developed were it, in turn, never to see the land.

#### HISTORICAL RESUME

A curious fact that all of us experience and frequently comment upon in automotive engineering is that we really re-invent more than we invent. Excellent develop-

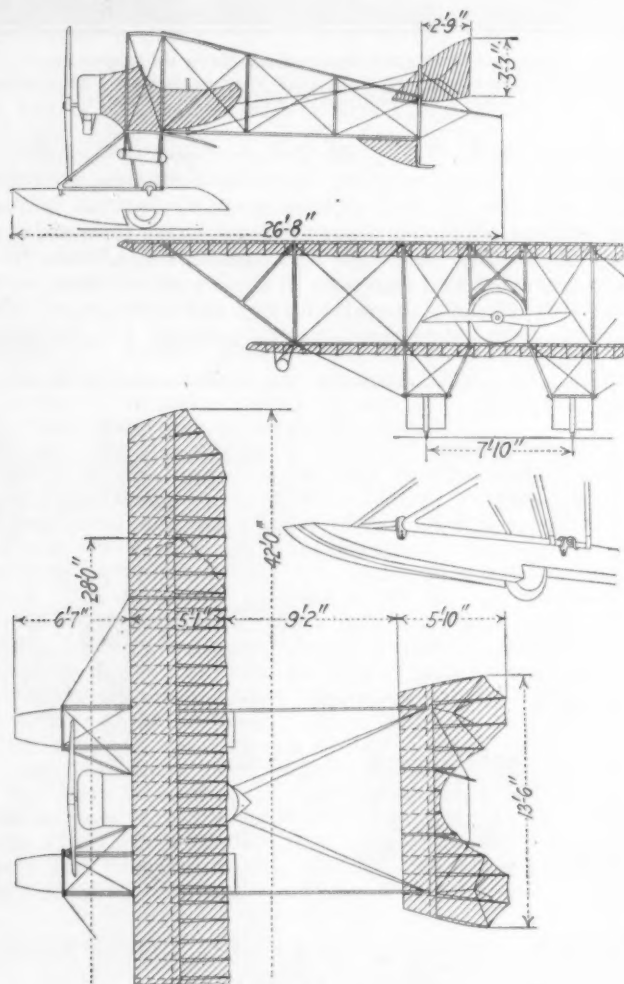


FIG. 3—THE CAUDRON AMPHIBIAN  
A Development Existing in 1912 and 1913, Being an Example of the First Really Practical Type of Amphibious Airplane

ments were dropped years ago for reasons that were good at that time but which do not hold true today, and this is particularly true in airplane development. The amphibious type of airplane was distinctly included in the very earliest conceptions of Ader in France and Dr. Kress in Austria, in 1898 and 1899. The Wrights, in 1907, experimented with floats on the Miami River and, in October, 1909, at the Hudson-Fulton Celebration in New York City, Wilbur Wright flew the first airplane that could in any way be construed as amphibious. Because of the large area of water surrounding New York City, Wilbur Wright attached to his land-type airplane, as shown in Fig. 1, a covered water-tight canoe with

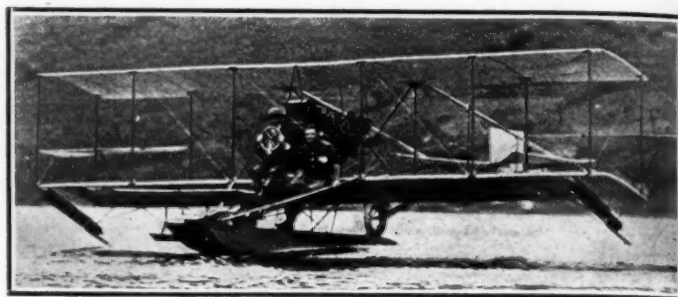


FIG. 4—THE CURTISS HYDRO-AEROPLANE OF 1912  
This Was Known as the Triad. It Was Equipped with Wheels That Enabled It To Be Run Up on Beaches, Runways and the Like

which undoubtedly he could have alighted safely on the water, but he could not have taken-off again.

On March 28, 1910, Henri Fabre made the first flight from water, in France, and contributed to the amphibian by giving the start to water flying. It is historically important to note that it was not until January, 1911, that Curtiss made his first flight from water. With the ensuing work of many of the constructors in France, and of Burgess and Frank Coffyn in this Country, a lively development of seaplanes took place in 1911, 1912 and 1913. In reviewing this period, however, it is interesting to find that the thought of making these early seaplanes amphibious was in the minds of almost every one of the early constructors. It was very common to find wheels at least fitted for the purpose of launching, and these naturally developed into efforts at landing on land so that, in 1912, several experimental amphibians such as are shown in Fig. 2 were in existence in various countries, but none of them were particularly successful.

The first really successful amphibian that was put to any serious use was the Caudron two-seater twin-float seaplane, shown in Fig. 3, powered with a Gnome 80-hp. engine. Several of these airplanes were adopted by the French Government. They were good flying machines and, as is evident in Fig. 3, the amphibious gear consisted in the mounting, at the step, of a wheel in each float. The great war began in 1914 and, as a concrete example of how little real help it was to the technical development of commercial aviation, further development of extend-

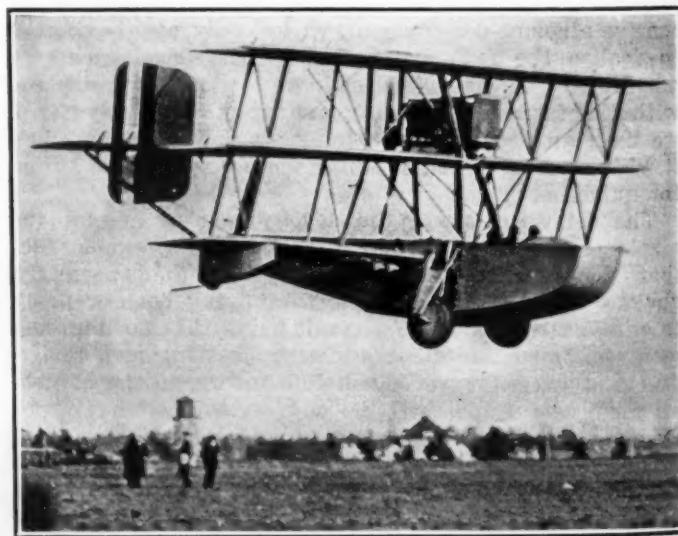


FIG. 5—THE SPERRY AMPHIBIAN  
It Was Built and Flown by Lawrence Sperry in 1919 and Was the First Successful Airplane of the Amphibious Type in This Country

## AMPHIBIAN-AIRPLANE DEVELOPMENT

457

ing the practical scope of the airplane by perfecting its amphibious qualities was abandoned and no progress whatsoever in this direction was made until the war was over.

In 1918 and 1919, a distinct revival of interest in the amphibian took place. In America, the first notable effort was that of Lawrence Sperry. Although some of the earlier Curtiss seaplanes that have been mentioned, one of which is shown in Fig. 4, made a few consecutive landings on land and on water, to Lawrence Sperry should go the credit of developing the first real amphibian in America, this being shown in Fig. 5. He was exceedingly interested in this phase of aviation and genuinely enthusiastic over its possibilities, and it is nothing but the irony



FIG. 6—THE LOENING SEAPLANE OF THE UNITED STATES NAVY  
The Undercarriage Was Equipped with Wheels and Was Constructed by G. Elias & Co., Buffalo. It Was Tested Successfully in 1922

of fate that the tragedy of Sperry's death, the drowning of this pioneer after having had to make a forced landing on the English Channel in a small land-airplane incapable of floating, on a perfectly quiet day, was due to the very cause that he had foreseen and that he had been working so industriously to avoid. The Sperry Amphibian had limitations, to be sure. It lacked maneuverability and may have had some minor structural defects, but nevertheless it was a real effort and full of originality.

Further development took place in 1922 and 1923. The Navy Department had developed a modification of one of our Loening seaplanes, in which wheels were inserted in the floats, as shown in Fig. 6. We experimented with this machine, and landings were made on land and on water. But here we have the same old story: Used as a land airplane the floats were of no value and, as a seaplane, the wheels seriously impaired the floats so that the entire airplane represented merely a subterfuge in development, that of adding wheels to a seaplane. However, our interest was stirred considerably, and it was at about this time that the design of the present Loening Amphibian was laid out. However, nothing could be done with it, as no inverted engine was available, and although I had suggested this idea to McCook Field authorities as early as 1919, it now became an urgent matter; so, we urged the engine builders again to realize the advantages of an inverted engine. In studying this matter, Henry M. Crane was of distinct service; he frequently and definitely expressed his technological opinion to all who were interested, that a Liberty-12 engine or one of similar type easily could be made eminently successful in the inverted position.

At about this time, the Dayton-Wright Company built a very interesting amphibian for the Navy Department. It was designed by Col. V. E. Clark and is shown in Fig. 7. This was a practical machine in every way and did considerable good flying. However, it still represented the old conception of fitting wheels to a regulation type of seaplane, although it was done rather more neatly than ever before. Meanwhile, a much more active development of amphibians was taking place in Europe.



FIG. 7—THE DAYTON WRIGHT AMPHIBIAN  
A Successful American Type Delivered to the United States Navy in 1923

The first real step after the armistice was the Vickers Amphibian. This represented the same old flying-boat type with its engine up between the wings and having a pusher propeller, with wheels that folded-up sidewise on either side of the hull. One of these airplanes was purchased by our Navy Department and was brought over to this Country, where we all had ample opportunity to

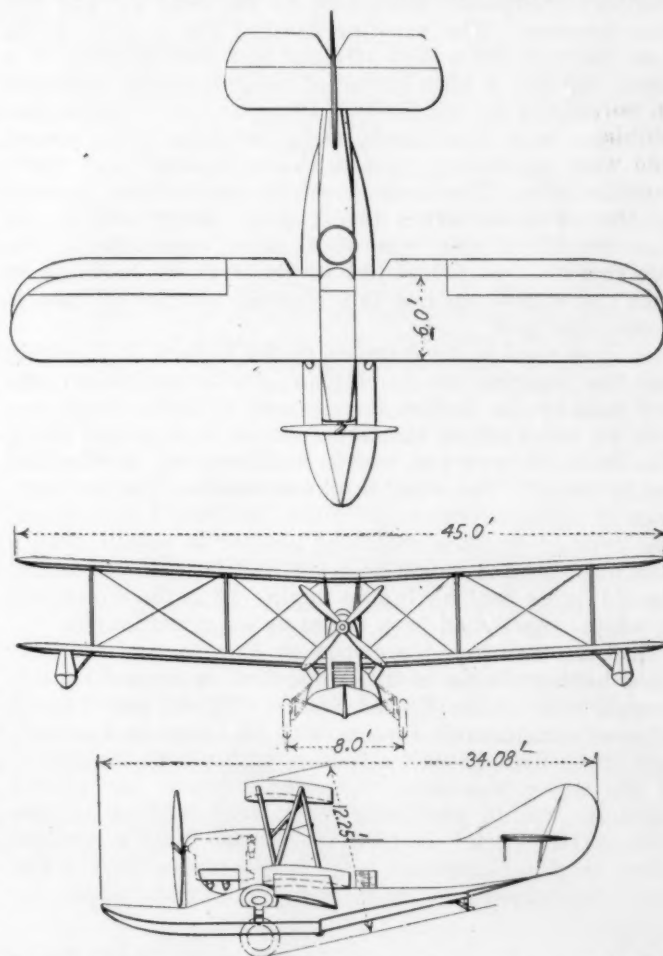


FIG. 8—PLAN VIEW AND FRONT AND SIDE ELEVATIONS OF THE LOENING AMPHIBIAN

Some of the Principal Details Are Given in the Following Tabulation

	Surface			Weight	
	Sq. Ft.	Sq. Meters		Lb.	Kg.
Total Wing	504.0	46.45	Empty	3,400	1,542.64
Ailerons	60.0	5.57	Fuel and Oil	800	363.88
Stabilizer	43.4	4.04	Crew	360	163.33
Elevator	28.0	2.60	Miscellaneous	1,000	453.70
Rudder	16.8	1.56	Total	5,560	2,522.55
Fin	10.8	1.00			



FIG. 9—THE LOENING AMPHIBIAN

This Machine Is Equipped with an Inverted Liberty-12 Engine

study it. So far as safety went, the type was distinctly bad for a land airplane, as the engine was over the backs of the crew and this was dangerous in case of a land crash. If it broke or had something fly into it, the pusher propeller was a constant menace to the tail. Two large head-resisting bodies, the engine nacelle and the hull, were presented to the airstream. The engine was difficult of access for maintenance purposes and, from a military viewpoint, protection to the rear by gun fire was hopeless. The machine handled like a good flying boat and not like a land airplane and, due probably to a short tail and a high center of weight, it was awkward in porpoising on the water. However, the Vickers Amphibians have done much useful work in many places, and were exceedingly well built and in every way workmanlike jobs. The dangers attributed to them, because of the tragic accidents to Sir John Alcock and to Sir Ross Smith in this type of airplane, were due to the fundamental characteristics of the type of machine in that the engine position is a constant menace in case of a crash on land.

A close rival in development to the Vickers in England, was the Supermarine Amphibian. In the amphibian contest held by the British Government in 1920, which was won by the Vickers, the Supermarine won second place. The Sea-Gull type was widely used not only in England but in Japan. The weights, characteristics and performance of these airplanes are given in Table 1. However, this type of airplane remained heavier to handle than a land machine and it will be noted that it still represented the old flying boat having its engine up in the wings and to which wheels had been added as an afterthought.

Still another type developed in Europe was the seaplane having wheels in the floats, such as we had experimented with in the United States. Fairey and Parnell achieved considerable success with this type in England, with small light pursuit-airplanes with which the get-off on the water was easy. This development has proved distinctly useful, particularly for deck landing in aircraft-carrier work. In fact, the British Navy's requirements in this connection have been responsible for the lively development of amphibians in England since the

war, although it has taken the form of fitting a seaplane in original thought with wheels as an afterthought.

In Europe, since the war, about the only other amphibian development of any note has taken place in France, where we find the gradual evolution from the old FBA flying boat to the present Schreck FBA Amphibian. This airplane is built either as a tractor or a pusher machine, although the engine still remains up in the wings as in the old flying-boat type. That the wheels were added as an afterthought is somewhat evidenced by the fact that they are not even fitted with shock-absorbers and, although apparently effective as a landing-gear, the tread is narrow and there is no "give" other than in the tire.

Typical of the highest developments of amphibians in Europe up to 1925 is the Supermarine Scarab. This type is particularly interesting, as it has seen actual war-service with the Spanish forces on the coast of Morocco. The details of this airplane are also given in Table 1 and, in function and in size, it can be said to represent the direct competitor in Europe of the Loening Amphibian. However, up to 1925 the adoption and use of amphibious airplanes has remained very limited, for the obvious reason that the amphibious types shown had not yet been made into real good flying-machines. They were all less efficient than either a good land-airplane or a good seaplane, were less handy in flying and more difficult to handle on the ground.

#### DEVELOPMENT OF THE LOENING AMPHIBIAN

In general, we can summarize the disadvantages of the general amphibian-developments that had taken place up to the advent of our new type, to consist essentially of the following points:

- (1) Poor flying qualities. Slower and heavier handling as a seaplane and more head-resistance in the air and on the water, due to the external attachment of the landing-gear
- (2) Dangerous as land airplanes, particularly in the flying-boat types of amphibian in which the engine is over the crew. The wide distribution of heavy weights, with the crew located in the bow of the airplane, constitutes a distinct menace over land. In addition, the propeller at the rear is a danger, and the weight being very much higher off the ground leads to difficulty in handling
- (3) The amphibious construction had not given any mutual advantage either to the land or the seaplane types
- (4) Poor efficiency and maintenance, and therefore highly expensive operation and less performance

This was the situation as we analyzed it several years ago and, fortunately, the successful development of the inverted Liberty-12 engine at McCook Field late in 1923 gave us a splendid powerplant of the type for which we had been clamoring so long a time; so, we proposed to the Army Air Service the construction of this new and novel type of *tractor amphibian* with the hull and body

TABLE 1—AIRPLANE CHARACTERISTICS AND PERFORMANCE

Airplane Type	Engine Type	Power, Hp.	Area, Sq. Ft.	Span, Ft.	Weight Empty, Lb.	Maximum Load, Lb.	Full Load, Lb.	Weight per Horse-power, Lb.	Weight per Square Foot, Lb.	High Speed, M.P.H.	Service Ceiling, Ft.
Sperry Triplane	Liberty-12	500	678	48	4,199	1,345	5,544	15.0	8.0	85	9,000
Fairey	Napier Lion	450	488	46	3,900	1,600	5,500	12.2	11.2	108	13,000
Vickers IV	Napier Lion	450	635	50	4,030	1,760	5,790	12.8	9.1	105	13,000
Supermarine Scarab	Napier Lion	450	605	46	4,125	1,875	6,000	13.3	10.0	103	11,000
Schreck FBA	Lorraine	450	535	47	4,150	1,990	6,140	13.5	11.3	109	14,000
Loening Amphibian	Inverted	400	504	45	3,400	1,800	5,200	13.0	10.3	124	15,000

complete as a unit, using an inverted engine with the propeller thrust at the extreme top of the body as shown in Figs. 8 and 9. At first, due to the admittedly strange appearance of the design, we found it somewhat difficult to make progress in interesting the Government, but the facts and figures on our weights and layout and on our wind-tunnel test were unassailable and to the officers of the Engineering Division of the Army Air Service belongs whatever credit is due for giving the real stimulus to this development by ordering the first machine. Since then, the Navy has pushed the development still further. Colonel Mitchell, who was at that time in charge of the operations of the Air Service, was somewhat opposed to the development of the Loening Amphibian, as he still had the outofdate idea that a seaplane never could be made into a good flying-machine. However, he was unconsciously convinced by a curious and, for us, fortunate coincidence at the time when a conference on this very subject was in session at McCook Field. Colonel Mitchell was on his way there by air from the City of Washington but, when beyond Moundsville, W. Va., and over the

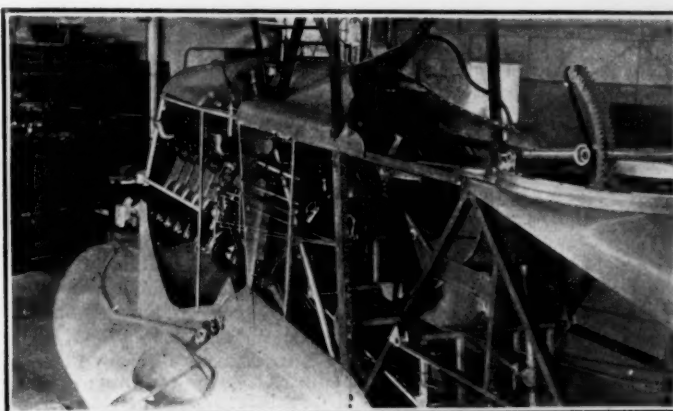


FIG. 11—DETAILS OF THE LOENING AMPHIBIAN  
This Photograph Illustrates the Framework of the Body and the Installation of the Inverted Liberty-12 Engine

Amphibians this year, and we see a growing demand for this type in all services; so, perhaps, after all the amphibious type has been established definitely for the simple and effective reason that it has been made into a good easily handled and efficient flying-machine. We claim to have accomplished this result for the following reasons:

- (1) Poor flying-qualities have been eliminated by adopting, or rather by reverting, to the most ordinary type of tractor biplane in which, however, by using the inverted engine and a careful distribution of weights, we take especial care to have the center of gravity and the center of lateral-fin area as nearly coincident as possible. This feature, which is one of the points in our patent, is of very great importance in the handling and flying qualities of the machine and was developed by us after extensive experience with other types of airplane including the old Loening Air Yacht. In these experiments we found one of the elemental reasons that airplanes handle badly to be simply that, in making turns, a low center of gravity may tend to overbank the airplane, or a large fin-area too far below the center of gravity may tend to unbank it when it skids. When the amphibian was first being built, there was considerable worry about the effect of the large side-area of the deep body but, due to our experiments, we were confident that if we put the center of gravity at the center of pressure of this side-area, we had nothing to worry about and tests have proved this point to be entirely correct. The airplane has shown in the air the very desirable characteristic of being under excellent control in a stalled condi-

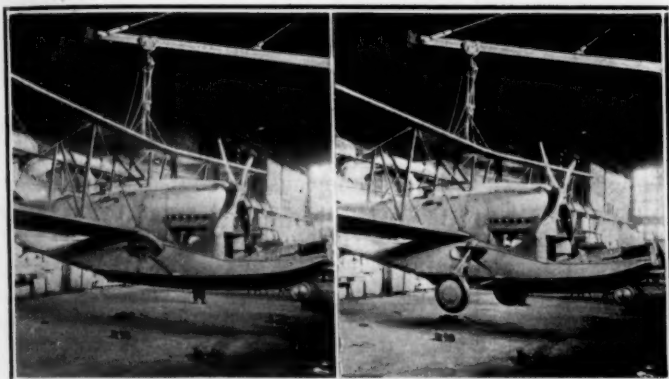


FIG. 10—LANDING-GEAR OF THE LOENING AMPHIBIAN  
The Landing-Gear Is Folded and Unfolded by Power That Is Furnished by an Electric Motor

Ohio River and while flying very low because of clouds, the engine went dead suddenly and he had no recourse but to land his DH airplane on the water. The airplane was a total loss. Colonel Mitchell and his mechanic had to swim to shore and very narrowly escaped drowning. The result was a very laconic message from Colonel Mitchell to me, to the effect that there was not very much argument about the desirability of amphibian development.

After constructing a preliminary model in 1924 for initial and sand tests, we proceeded with the development. In January, 1925, Lieutenant Brookley accepted delivery of the first airplane of a group constructed for the Army Air Service and proved definitely, in the air, the claims that we had made for this design; namely, that with the same powerplant as for a DH machine and 100 to 200 lb. of additional weight, we would take-on the Army's best airplane of the DH type and show that this amphibious flying-boat could out-fly, out-maneuver, out-climb, and out-speed the DH airplane in every item of performance. This was done right down the list of performance requirements and probably is the first time in the history of aviation in which the flying boat has come into its own by showing definitely that it is just as good a flying machine as the land airplane. Since then, about 17 Loening Amphibians have been completed and, in the short space of 1 year, these machines have been put to work in all climates from the Arctic to the Tropics and have been employed for a wide variety of uses. Already, over 100,000 miles have been flown by a few Loening

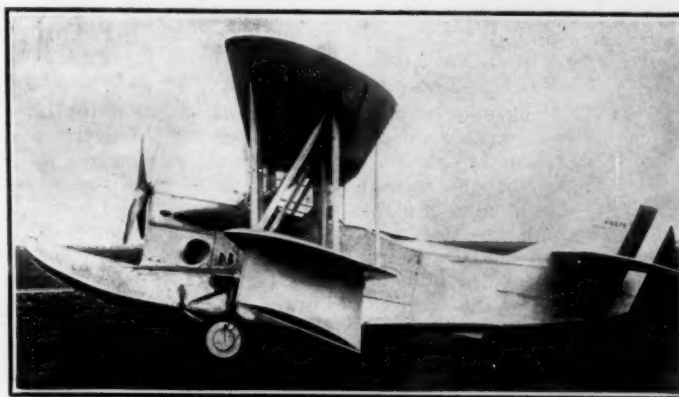


FIG. 12—SPECIAL TYPE OF LOENING AMPHIBIAN  
This Machine Was Developed for the United States Navy, Equipped with a 500-Hp. Packard Aircraft Engine and Designed with Special Features for Catapult Launching, Deck Landing and the Like

tion, and another point that has added to the flying qualities is the high thrust at the top of the body which has given an excellent longitudinal stability

- (2) Safety of the machine as a seaplane type subject to forced landings on land was instantly accomplished by the tractor engine-position and by the enormous strength of uniting the float and the fuselage into the large husky body. In addition, the projection of the body at the nose under the propeller tends to keep the airplane from turning over, if landings are made in high wheat or corn, and the machine taxis on the ground practically the same as a land airplane of equal weight. Handling is normal on landing and take-off, because the actual center of gravity when the airplane is on its wheels is lower than the center of gravity of a DH airplane
- (3) There is distinct advantage of the land and water features to each other. The unit hull and body has given greatly increased strength to the fuselage as a land airplane and above all has given one of the most interesting advantages to this

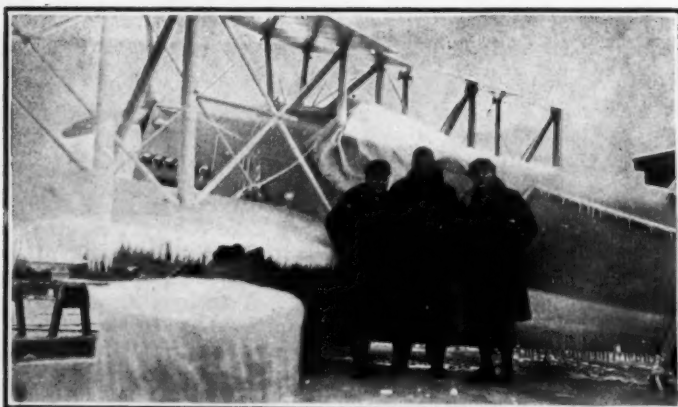


FIG. 13—WINTER CONDITIONS OF FLIGHT  
Loening Amphibian Used at Duluth by Lieut. Eugene Batten, of the Army Air Service, in the Photographic Survey of the Canadian Boundary; It Operated Successfully under Extremely Difficult Weather Conditions

type of airplane, namely, an extraordinarily large amount of room for load carrying because every bit of the flotation element of the airplane remains of full use when the craft is used as a land airplane. When used as a seaplane, there is no disadvantage due to the wheels, on account of the manner in which they fold into the hull, and there is every advantage for two very good reasons. One is that of being able to open the wheels out and slow down the machine when traveling through the water to assist greatly in taxiing, and the other is that when the wheels are out they serve as an excellent launching truck to take the airplane up and down runways, as shown in Fig. 10

- (4) The efficiency and maintenance of the airplane is considerably improved over that for other types of amphibian, mostly for two reasons. The amount of external landing-gear due to mounting it at the chine edges of the hull is very small and has reduced the head-resistance, even with the gear unfolded, to such an extent that the land airplane is rivalled in performance, and that of the seaplane is in no way reduced. With the inverted engine mounted forward and walkways on the side of the hull, the accessibility of the engine for maintenance and the ease with which engines can be put in and taken out, the spark-plugs and the distributors cleaned and the like has been a revelation to the crews at service-stations

In short, the invention of the Loening Amphibian has consisted essentially in converting a tractor airplane into a flying boat by inverting the engine and building the fuselage as a husky boat-hull. There is no fundamental waste of weight or duplication in the design, and even the external part of the landing-gear, the wheels and the small elements fastened to the edges of the hull, amounts only to about 180 lb., all the interior hull-framing being required in any case as part of the support of the airplane on the ground. The greatest practical advantage to the airplane has been found to be the extraordinary amount of room in the unit body and hull.

This type of airplane has been looped and spun and stunted in exactly similar manner and as easily as the best land airplane of equal weight. Among the interesting and important constructional details, mention should be made of the electrical operation of the landing-gear, which takes only 4 or 5 sec., and the hull construction that is entirely metal-covered throughout, using duralumin, which is fastened by duralumin bolts to wooden stringers as indicated in Fig. 11, giving a remarkably water-tight and serviceable job. Great care, however, is to be taken to separate the duralumin sheet and the wood by a layer of fabric impregnated with bitumastic. The use of bolts instead of rivets or wood screws is the result of a very careful study and is particularly desirable in that it makes the protection of the bolt against corrosion in salt water much easier, because each individual bolt can receive numerous coatings of enamel or bitumastic, if desired and, in being fastened to the hull, it is not hammered like a rivet and therefore is not likely to lose its heat-treatment against corrosion. Up to now, only one coat of bitumastic has been used on the bolts, and airplanes that were 5 months out at sea with the Navy's Arctic Unit and subject to severe weather conditions, came back in remarkably good condition. However, any amount of protection can be given the bolts, which is not true of rivets. The wood frame seems to have enough resiliency to take up the severe local-strains of the land operation of this airplane to prevent leaks from developing, which has always been a serious cause of trouble in amphibians.

The wing structure is metal framing, covered with linen. The ribs are made of duralumin by a machine-tool process, specially developed in our shops. Table 1 gives comparative weights and performances for several types of amphibian. From this it will be seen that, although its safety factor is considerably higher than that of any of the airplanes listed, the Loening Amphibian is 10 or 15 per cent lighter than any of the older types, none of which, however, are built in any way of metal construction.

#### SERVICE USES OF THE LOENING AMPHIBIAN

This new type of airplane, shown in Fig. 12, has been ordered by the Army Air Service, by the Bureau of Aeronautics of the Navy and by the United States Marine Corps for a wide variety of uses. It is an excellent airplane for photographic purposes; it is useful as a coastal reconnaissance airplane and is an ideal cross-country machine, as well as being a type that is suitable for use from shipboard on aircraft carriers.

Evidence of the versatility of this type of airplane is found in the records of expeditions and in cross-country trips already made within the last year. Among these are the photographic survey of the Rainy Lakes region near Duluth, by Lieutenant Batten of McCook Field, with the equipment shown in Fig. 13; the tour of New England made by the Secretary of War; the various

flights of Brookley, Meister and other Air-Service pilots between New York City, the City of Washington and Dayton; the operation of the Naval Arctic Unit, under the able leadership of Commander R. E. Byrd, with the MacMillan Expedition, using the equipment shown in Fig. 14, in which 6000 miles of the most dangerous and difficult kind of flying was done in 12 flying days over the arctic wastes shown in Fig. 15; and the Hydrographic-Survey operations now being conducted in Cuba, where the Navy Department has sent two exactly similar airplanes to those that did such arduous work in the Arctic. At Mitchel and Langley Fields, at other Air-Service stations and at the Naval Air Station at Anacostia, operations and service use of this type of airplane are in progress continuously and are giving us a splendid opportunity to whip into shape every mechanical detail requiring perfection in this new type of airplane.

#### THE AMPHIBIAN'S COMMERCIAL FUTURE

The most interesting part of the amphibian's work will be its use in commercial flying. Let us study the time wasted in flying from New York City to Detroit, or to Chicago, not in the flight from field to field but in traveling from hotel to hotel. In New York City, we waste at least 1 hr. in trying to get from the city to the field at Mineola, on Long Island; at Detroit, we waste very nearly 1 hr. coming in from Selfridge Field and yet, between the two, we certainly need to have a land airplane. In New York City, however, we have the Hudson and the East Rivers, the latter at our own airport, only about 4 min. from the Commodore Hotel; in Detroit, except on a few very icy winter days, we could land at the foot of Woodward Avenue, a short walk of the business center. These 2 hr. of wasted time in a trip of some 700 miles over the airways at a cruising speed of 100 m.p.h. means that, if I were starting from the hotel to use an amphibian at the same time that some one else started who was going to use a land air-



FIG. 14—BASE OF THE MACMILLAN ARCTIC EXPEDITION AT ETAH, GREENLAND

One of the Navy's Airplanes Is Shown Set-Up on the Beach and, in the Harbor, the Small Vessel Peary That Carried the Airplanes to the North Can Be Seen Lying at Anchor. The Difficulties of Flight in This Region Are Apparent



FIG. 15—THE ARCTIC WASTE

One of the Views Taken from the Air of the Arctic Waste Flown Over by the Loening Amphibian Used by the Naval Air Unit of the MacMillan Arctic Expedition. The Ice-Foot of the Glacier Shown Is Several Hundred Feet High

plane, I would be in an office in Detroit when the land airplane had only reached Moundsville, W. Va. On a short trip, such as from New York City to the City of Washington, it is of course ridiculous to add 1 hr. to a 2-hr. trip just because one uses an outofdate type of commercial airplane capable only of flying from land. The same is true at Philadelphia, Chicago, Cincinnati, Galveston, New Orleans, and San Francisco; in fact, if we study the Air-Mail map of the Country, it is interesting to point out that the operation of the Air Mail by amphibians would save time, by landing directly at terminals at practically every big station on its route, even as far west as Cheyenne, Wyo., and at Omaha, Neb., where, through most of the year, landings could be made on the Missouri River at a dock so near the Post Office that one could almost throw the mail to it; and yet, at present, fully 1 hr. is spent in driving in over a rough country road, from the landing field at Fort Crook.

In cross-country flying, we hardly need argue the enormously greater factor of safety due to having double the possible landing-places in case of emergency. In fact, even a greater element of safety exists since, in thick weather, river courses can be followed in many sections with ability to land at almost any time. We talk of mapping-out airways, and yet, so far as amphibians are concerned, we cannot have finer airways than we have on the Coast, marked as they are so distinctly that one cannot miss his way in thick weather, nor can we have better lines of travel than over the Hudson, the Ohio, the Mississippi, the Missouri, and other rivers. Then consider flying over the Rocky Mountains where most of the landing-fields are, unfortunately, nearly vertical; and yet, a route could be selected over the Rockies that would pass over various lakes and reservoirs and that would represent, from a standpoint of landing-fields, a very reasonable degree of safety to the amphibian. One other point is of cardinal importance commercially; that is, the saving from a commercial standpoint in using amphibious airplanes, of not having to spend a great amount of money in the big cities for airports, owing to the necessity of having to acquire valuable property for that purpose.

In Europe, much the same condition exists, particularly so far as the Mediterranean countries are concerned, and certainly in the case of the air lines from London to Paris and from London to Amsterdam. We know of about 12 forced landings of passenger airplanes on these lines in the English Channel since the war and the drowning of some 14 passengers. Many have had the disturbing experience of starting out from Boulogne in these land types of airplane for a slow and tedious trip of which a 40-mile stretch is over water, where they know they have little or no chance in case of a forced landing. This condition is absolutely wrong in commercial aviation, and to tolerate it is a great mistake.

There are, therefore, three cardinal advantages of the

amphibian for commercial work. First, time is saved by having the terminal at the city all ready-made for it; second, danger of cross-country flying is greatly lessened by the use of this type; and third, money is saved to commercial enterprise by not needing extensive landing-field property-acquirements.

We reach, therefore, what should be the obvious conclusion that, in having endowed the amphibian type with proper flying-qualities, with safety in construction and with convenience in maintenance and load carrying, we

may have stimulated and pointed the way for this type of airplane so that the very term "amphibian" will eventually disappear and, in the future, all efficient commercial types of airplane will become amphibious as a matter of course. Finally, we will look back on our limited seaplane or our limited land-airplane of today with the same amused superiority with which the present airplane with wheels can be imagined to regard the former old "crates" equipped only with skids and that needed a launching track.

## CRUDE RUBBER

AS recently as 1910 the rapidly developing automotive and rubber products industries had to depend for 91 per cent of their rubber upon the wild product gathered by natives from widely scattered trees in the jungles of Brazil and Africa. The limited supply thus made available drove the price of rubber in that year up to the high point of \$3 per lb. The average for 1909 was \$1.48 per lb. The high price of rubber had meanwhile stimulated planting on an extensive scale, so that by 1914 more than 60 per cent of rubber produced was from the plantations in the Middle East, and by 1919 the plantation output began to assume an aspect of overproduction. Although further planting on a large scale was discouraged after that year, rubber still continued to command profitable prices. In the summer of 1920, however, rubber prices started on a downward career, bringing about a depression that, in view of the huge accumulation of stocks resulting from the decreased demand, continued unabated in 1921 and 1922. The price of rubber declined from a monthly average of 55 cents for January to 17.5 cents for December, 1920, and the average price for 1921 and the first 10 months of 1922 was about 17 cents.

The development of rubber plantations had involved the risking of large amounts of capital in a pioneer industry. Labor had to be imported to clear the jungle and plant the trees and later trained and organized to gather and prepare the rubber. An expensive plant, including homes, huts and hospitals, as well as plants for the preparation of the latex tapped from the inner bark of the rubber trees, had to be erected. Six years must elapse, moreover, before the trees yield to any considerable extent and several more years are required before they attain what may be called full bearing.

It cannot be said that the Stevenson Act drove rubber prices up to unreasonable levels during the first two years of its operation. In the face of increased rubber demand arising from improved business conditions, the average monthly price during 1923 was less than 30 cents, the maximum price reached being 37½ cents. The temporary slackening in the rubber manufacturing industry during the first part of 1924 resulted in the price for the first three quarters averaging between 20 and 25 cents and in May rubber sold as low as 17½ cents. World stocks meanwhile were being depleted, because of the fact that for almost 2 years consumption had been outstripping production, and with the sharp recovery in business in the fall of 1924 prices rose to nearly 40 cents by the end of December.

The low prices that had prevailed earlier in the year had meanwhile reduced the export quota from the British possessions for the last quarter of 1924 to 50 per cent of standard production. The allotment was raised to 55 per cent for the period from February to April, 1925, and a 10 per cent additional release was effected for each succeeding quarter of 1925. These releases were evidently not sufficient to meet the heavily augmented demand from the United States. The cautious buying policy of American manufac-

turers which had helped to maintain prices at a low level in 1924 had left them with extremely short supplies of crude rubber.

The low prices of 1924 were now also limiting indirectly, through the operation of the Stevenson Act, the output from the major source of supply. As a result stocks in London, the only source of spot rubber, had been reduced from the comparatively low level of 30,000 tons at the beginning of 1925 to about 5000 tons by the middle of the year. Prices rose from an average of 36 cents in January to the average of 77 cents in June, and attained a peak of \$1.21 on July 20, when a sharp reaction took place, sending the price down to 72 cents early in August. About the middle of August the upturn in prices was once more resumed and continued for 3 months until it reached the high level of \$1.10½ on Nov. 23. The December market showed a decline from \$1.06¼ to 91 cents on Dec. 31, due to liquidation of London speculators on the long side and the more comfortable position of the large American consumers, who had provided in November for their early 1926 requirements. Trading in the present year began with a price of 87 cents. The price declined to 70 cents during January, and after remaining relatively firm in the first half of this month, resumed a distinct downward trend.

The serious problem now facing the rubber industry is that with the present rubber acreage and the probable annual increase in rubber consumption we are confronted with a prospective rubber shortage within a few years. This analysis is, of course, based upon the maintenance of the present technological and psychological basis. The increased use of reclaimed rubber and of rubber substitutes may upset these calculations. The vagaries of consumption in the face of extremely high prices must also be reckoned with. Under the stimulus of high prices the production of reclaimed rubber in the United States has increased from 179,200,000 lb. in 1924 to 320,320,000 lb. in 1925. The Department of Commerce calls attention to the growing capacity of the reclaimed rubber industry, and estimates that about 448,000,000 lb. will be produced and used in 1926. It must be observed, however, that with present methods of reclamation only from 10 to 15 per cent of reclaimed rubber can be used in tire production.

At the present time less than 4 per cent of rubber investment is in the hands of American capital. Practically none of it is domiciled within our political jurisdiction. Labor and climatic requirements do not promise a great development of rubber plantations outside of the Middle East in the near future.

The increase in exports from the unrestricted areas in the Middle East was more than sufficient to offset the reduction of shipments from British possessions in 1923 and 1924. It appears that the relative proportions of exports from restricted and unrestricted areas were about the same in 1925 as in the preceding year.—*Guaranty Survey.*



# Motor-Transport-Field Opportunities for the Automotive Engineer

By J. EDWARD SCHIPPER<sup>1</sup>

BUFFALO SECTION PAPER

## ABSTRACT

**R**ANGING from the most careful of operating and maintenance-cost supervision all the way down to the most colossal ignorance and carelessness that it is possible to imagine, motor-vehicle fleet-operation presents a vast field of opportunity for improvement that an automotive engineer is well qualified to till, and it is with the specific needs of this phase of business and the special qualifications required for successful supervision of it that the author deals.

Statistics are cited to illustrate the present magnitude of truck and motorcoach fleet-operation. It is said that automotive transportation, now in its infancy, will require efficient operating methods, including education of the operators as to the need of these methods, and automotive engineers to act as operating executives. In the next few years, the average cost of truck operation will be reduced far below the \$1,000-per-year mark it now sets. It is the automotive engineer, trained to purchase supplies intelligently, to handle maintenance efficiently and, understanding the problem of operation, to get the most out of vehicle and driver, who will cut this cost. No field of endeavor presents a greater opportunity, and three letters from operators of large fleets are quoted to emphasize the fact and specify some of the practical needs.

**A**N amazing situation exists today in the field of automotive transportation. It has come about so gradually that we are aroused to it with much the same feelings as those experienced by a man who has been walking in his sleep and is awakened to find himself in unusual surroundings, with only the vaguest idea as to how he got there. We have slipped so easily into motor transportation and gone so irretrievably far into it that many have feared to take stock of what it has cost and what it is costing, and to find out if we are getting what we are paying for.

The big operators of motor transportation in this Country long ago awakened to the fact that they had to free themselves from "horse" methods to utilize fully the greater efficiency of the motor truck and to escape the penalty of wasting ruinous sums of money. The big motorcoach companies, oil companies and organizations like the Western Electric Co., the American Railway Express Co. and the Western meat-packers, which operate tremendous fleets composed of thousands of vehicles, have transportation departments that are as efficient and highly organized as the operating departments of a railroad system; but, turn to the operators of medium and smaller-size fleets who, in the aggregate, operate about 40 per cent of the 2,500,000 trucks on the streets and roads of the Country, and you find anything from the most careful of operating and maintenance-cost supervision all the way down to the most colossal ignorance and carelessness that it is possible to imagine. The medium and the smaller transport-users of this Country do not realize that they are paying a staggering bill for transportation; a bill that could be immeasurably cut

down were the same engineering and business principles applied to the transportation departments as to the manufacturing and sales. Newspapers, department stores and stores in other lines of business exist whose delivery cost clearly represents the difference between profit and loss on the entire business. Gradually, the knowledge of this is growing throughout the business world, and herein lies the opportunity for a big percentage of the automotive engineers of the future.

## OPERATING AND MAINTENANCE OPPORTUNITIES

Just as in other transportation fields, the railroad for instance, the opportunities are greater, or rather more numerous, in the operating than in the designing field, so, as time passes, will the ratio of opportunities in the operating and maintenance field grow in proportion to those in the other branches of the industry. Of course, a demand will always exist for engineering talent in design and manufacture, but let us draw aside the curtain and disclose some of the possibilities we can now begin to visualize in the field of operation and maintenance.

One way to define an engineer, and a way that most executive heads of manufacturing companies will agree to, is to say that he is "a man who can spend money scientifically." Some executives will add the words "and rapidly" to that definition. However, in practically any line of work in which the ability of an engineer, or his value to his company, is measured, he is judged by his ability to spend the money of his employer in such a way that the return for the money is the greatest. The research engineer who spends thousands, or even millions, for a great corporation, and develops a new product that opens up new markets, may net tremendous returns on the money spent. Of course, some historic incidents in our own industry in which the money did not come back can be recalled, but those are the exceptions that prove the rule. The designing engineer will cost his company thousands in the development of a new model, but if he is a good designer the money comes back many times over. So also the production engineer, in designing new production methods and in purchasing costly jigs, dies, fixtures, and tools, knows that the money will come back many times over in reduced cost of production.

Thus, also, that comparatively new man, the transport engineer, just beginning to be recognized in our industry as well as outside it, can save untold sums to the users of motor transportation. His opportunities are 10 times as great because 10 times as much money is spent today for the operation and maintenance of trucks and motorcoaches per year as is spent in building them. Over 2,300,000 trucks and 70,000 motorcoaches are now on the road. Production is running at the rate of over 500,000 trucks and motorcoaches per year. Eliminating sales costs, overhead and the like, it costs somewhere around \$200,000,000 per year to build these vehicles. The average is low because about 75 per cent of the production is in the 1-ton class and under, such as the

<sup>1</sup>M.S.A.E.—Eastern representative, Chilton-Class Journal Co., Philadelphia.

Ford and the Chevrolet. In other words, the engineers who are in the designing and production field must guide the expenditure of \$200,000,000 annually. The men who are in charge of the operation of these vehicles over the highways spend the staggering sum of \$2,000,000,000 annually. And this does not include the money spent for shop equipment, garage buildings and the like, which in themselves represent millions of dollars; neither does it include the salaries of drivers or of mechanics but simply the money actually spent in operating the trucks and motorcoaches.

Not many industries spend this much money annually, and not any, except perhaps that which made Hollywood famous, spends it more carelessly or, rather, less scientifically. Not very long ago a large Chicago department store had a suspicion that it was costing too much to operate its delivery fleet. A certain automotive engineer was called in to analyze carefully the delivery costs, to go into the building of the trucks, study the routing and the like and see what he could do. He saved the operator of that fleet of delivery trucks \$90,000 per year. To the man who is in the truck business the amazing part of this is not the fact that the fleet owner was saved \$90,000 a year, but that he was open-minded enough to call in the engineer. The fleet owner did not know he was suffering from a business sickness, but he suspected it; so he called in the doctor. Now this company follows the ancient Chinese custom of keeping a doctor on the job while the patient is well, to see that the business does not become sick again. The ostrich type of fleet operator is becoming more rare as time goes on, but he is still with us.

#### AUTOMOTIVE-TRANSPORTATION-FIELD REQUIREMENTS

It is still a source of wonder, even among those who are spending their lives in the business, why it is that a man will hire a trained engineer to take care of his heating plant or his elevator system, which may represent an investment that is only a fraction of what his fleet represents, and then take a graduate driver, who may not have the slightest executive ability, and put him in charge of a fleet of vehicles, the operating cost of which may make or break the company owning it. Herein lies the crying need for men trained in the requirements of automotive equipment, who are willing to learn the practical end of fleet operation and also to cultivate executive ability. To be a success in this great field, an adaptable, versatile type of man is required. Above all, he must be practical.

Not every automobile engineer who has a technical-school diploma or has made an outstanding success over the drafting board can sally forth as a transportation engineer. Neither are all or nearly all of our truck and motorcoach fleets poorly handled. But the big automotive-transportation field, now in its infancy, will require two things:

- (1) Efficient operating methods, including education of the operators as to the need of these methods
- (2) Automotive engineers to act as operating executives

We have no idea today just how big the automotive-transportation field will be. We know that in 1925 we had the biggest year in the production of trucks and motorcoaches that we have ever had. We know that over 500,000 trucks and about 35,000 motorcoaches, taking in all classes of the latter, will be built during 1926, unless some unseen circumstances arise. Last year we made about 480,000 trucks and 20,000 motorcoaches

So far as motorcoach production is concerned, it is simply a matter of how many the factories can turn out; the productive ability in the motorcoach field is not up to the sales requirements.

Operators of trucks and motorcoaches are called on to spend annually for:

Brake-Lining	\$19,000,000
Tires	200,000,000
Gasoline	300,000,000
Oils and Greases	48,000,000
Replacement Parts	120,000,000
Batteries	10,300,000
Bearings	18,960,000
Piston-Rings	5,740,000
Springs	13,600,000

These figures, compiled for 1925 by the research department of the company with which I am connected, are very conservative. The 1926 requirements will be greater. These examples are typical. The figures do not include any part of what is spent for passenger-car maintenance.

The growth of road transportation, both passenger and freight, is measured by the growth of the highway system. In 1925 11,329 miles of Federal-aid highways were completed. The United States now has 500,000 miles of hard-surfaced roads. Small wonder that the internal commerce is passing more and more over the highways, particularly in the urban and interurban short-haul work. Not only has the railroad ceased to consider the truck a competitor, but it is now considering it as an ally. Thirty-five railroads are now using trucks for terminal service, local freight-trains being replaced in 14 cases. Many instances are recorded in which railroads have turned short-haul losses to profits by the substitution of trucks, with consequent elimination of terminal congestion and the economy of door-to-door delivery.

To the young man entering the automotive-engineering field, the operating branch presents untold opportunity. Like all lines of work in which evidences of efficiency are measured in terms of savings to the employer, the successful engineer in this vocation has opportunities for more than the usual income. The field is in its infancy. In the next few years the average cost of truck operation will be cut far below the \$1,000-per-year mark it now sets. It is the automotive engineer, trained to purchase supplies intelligently, to handle maintenance efficiently and understanding the problems of operation to get the most out of vehicle and driver, who will cut this cost. No field of endeavor presents a greater opportunity.

I cite some interesting figures showing the expense of one operator of a small fleet, only 55 trucks. Some of the items will surprise you; the figures represent cost per year. The business of the company is general transportation.

Nuts and Bolts	\$283.99
Piston-Rings	9.80
Ignition Repairs	800.00
Cylinder Regrinding	309.00
Spring Leaves	778.00
Bronzes	155.37
Lighting Equipment	224.92
Woolens and Sponges	30.92
Miscellaneous	118.50
Fire Extinguishers	....

I went over the figures of about 200 operators who kept their costs. It was very interesting how close to \$1,000 per year the figures ran, not including the salary of the driver, overhead on shop equipment or the shop equipment itself.

## LETTERS FROM OPERATORS

To ascertain the feeling of operators as to automotive men going into this field and to find out what they thought of having men who had been trained in executive work also, we sent letters to fleet operators. One reply signed "L. V. Newton, Pure Oil Co., Columbus, Ohio," was as follows:

The question as to what position the automotive engineer should take in the operating end of the business is not new by any means. Prior to the war, however, very few companies operating trucks recognized the importance of having an automotive engineer in charge of their truck or passenger-car operation. I first began fleet-operating work in 1913 with a public-utility company at Chicago. The only reason in the world that I was given charge of automobile operation was that the costs were tremendously high, the service rendered poor and no one in the organization knew what the reason was. It was recognized that the problem was not one for a mechanic to cope with, but rather an engineering problem to be dealt with as such. In a few years the transportation costs of this particular company had improved to such an extent that I was asked to assume charge of the equipment of one of the large oil companies. Since that time I have revamped the motor-vehicle transportation of another oil company. Today, executives of all large companies and corporations operating great numbers of trucks recognize the necessity for having one man in control of such operation.

Coming to a company, an automotive engineer should be given charge of the motor transportation division, reporting to one of the executives of the company or, better still, to the executive committee. His field of endeavor will vary considerably, depending upon the number of vehicles to be handled and whether they are located in one town or city or scattered throughout the Country. His problem is to build up a field organization to take care of mechanical work, as well as to build up a suitable supervisory organization. To operate the vehicles in his charge intelligently, an accurate cost-system has to be installed. He must study costs to evolve methods of transporting goods more cheaply and more efficiently, and at the same time build up the mechanical condition of the vehicles, as well as their appearance, to the point where the vehicles in the field represent an asset instead of a liability. I have always said that if all large companies operating motor vehicles would operate them along the same lines that the railroads operate their locomotives, the transportation costs of the former would be very much decreased.

Another letter is from a fleet owner, Chester W. Sater, of the Atlantic & Pacific Tea Co., Jersey City, N. J.

In many businesses the importance of motor transportation as a definite activity has been little understood or considered. Many companies require motor transportation; many could scarcely exist without it. Yet most of these regard the operation of their motor fleets as a necessary evil and pay little attention to it, although the cost involved exceeds in many cases that of any other department. A probable reason for this neglect and indifference is that motor transportation is a comparatively new activity. Without question a need for properly qualified men in the field of transportation exists.

The problem, as I see it, is one of educating the companies. Certain large companies have made intelligent and complete studies of their transportation problems and, as a result, tremendous savings have been effected by more intelligent selection of equipment and recognition of the fact that a truck's purchase-price represents but a small part of its ultimate cost. These

companies have learned that the expense to them of the services of an efficient engineer is small when maintenance and operating problems are effectively handled. That the job can be handled best by an automotive engineer goes without saying, since it requires training of a technical nature, supplemented by practical experience and analytical ability. If opportunities open up more slowly in the industrial field, where they are greatly needed, they may open sooner in motorcoach transportation, which is expanding rapidly and becoming more popular here and abroad.

A third letter is from Arthur J. Slade, consulting engineer, New York City.

Drawing on my own experience of several years' connection with railroad engineering previous to my entry into the automotive-engineering field, the similarity between railroad and motor transportation appears to me to be marked. My observation in the former field was that the men who became the most outstanding successes started in relatively unimportant positions and, after a rather general apprenticeship, developed in some one of the several specialties such as construction and maintenance of way; shops and powerplants; locomotive and rolling-stock design, construction and maintenance; freight and passenger traffic-management; general direction of transportation; and executive management.

For the automotive engineer who has specialized in the design, construction and servicing of motor vehicles, the specialty in motor-transportation organizations in which he could utilize his talents most effectively apparently would be in the department which the Europeans describe as "engineering," which has a broader significance than in this Country, involving not only technical engineering but construction and administration in matters relating to the vehicle equipment, or the tools of the business.

The functions of general administration—financial, legal, direction of operating, personnel including employment and training, publicity and public relations, and such other activities as are necessary for the successful conduct of a transportation system—seem to be outside the immediate scope of the automotive engineer whose training and experience have been largely of a technical character. But, as in the railroad field, particularly as employed in the system of promotion existing on the Pennsylvania Railroad, where a man will serve for a time in all the specialized departments and eventually, on account of his peculiar aptitude and ability, become the chief operating executive, certainly no reason exists why the technically trained automotive engineer should not, if his natural abilities tend in that direction, assume a high executive position eventually. However, I am inclined to the belief that, with a background or foundation in general business-administration, the opportunities of becoming the head of a motor-transportation system are greater than with a purely technical engineering-foundation.

I know of one case in which a department store had a fleet and was placing floorwalkers, green men, in charge of motor-vehicle operation. On the other hand, a fleet operator in the delivery business in New York City, who has 150 trucks, put a man on the job of taking care of the maintenance and operation of these vehicles at a salary of about \$4,000. The first year the man saved \$25,000. Today that man has a steady job at about \$12,000; and last year he saved another \$15,000. An engineer and executive today can save his cost many times over. That sort of work is appreciated very much, not only by the man, but also by the people who employ him. Money saved in fleet operation in some cases means a neat profit on the entire invested capital of the business.

# AIRCRAFT-ENGINE-INDUSTRY ACHIEVEMENTS<sup>1</sup>

**O**UTSTANDING features of American aircraft-engine development since the stabilization of the industry, finally achieved subsequent to the World War, include a great reduction in engine weight accompanied by an increase in reliability, the development of large engines, the working out of the fundamentals essential to the production of satisfactory air-cooled engines of any desired power output, the development of highly satisfactory reduction gearing; and the successful solution of the supercharger problem.

The greatest success in the development of large engines has been attained by following closely the design features of the smaller sizes. In the 600-hp. class, the Wright T-3 engine weighs approximately 1.95 lb. per hp. and, in the 800-hp. class, the Packard 1A-2500 engine weighs 1.45 lb. per hp., each being representative of the development mentioned. The dry weight of water-cooled engines has been reduced from approximately 2.25 lb. per hp. to about 1.40 lb. per hp., which has been attained by several engines of recent design. The best figure recorded is 1.31 lb. per hp., attained by a Curtiss V-1400 engine; it passed a satisfactory endurance test at a 510-hp. rating and weighs 670 lb. The engine has been operated at a 605-hp. output, representing a weight of 1.11 lb. per hp., but no long endurance test has been made at this output. Painstaking attention to detail in following conventional lines of construction is credited for these successful results, and the introduction of novel mechanisms or new principles is said to have had no part in the foregoing development. Refinements of engine types available at the end of the war consist mainly in greater compactness of design, providing lighter weight and greater rigidity in the employment of higher crankshaft speeds and in improvements of valve-operating mechanism, valve materials, valve cooling, bearing design, and volumetric efficiency. The most promising line of development appears to lie in the direction of higher crankshaft speeds.

## NEW TYPES OF ENGINE

Possibilities of other mechanisms superior to the conventional crankshaft, connecting-rod and poppet-valve combination are in prospect. Two novel types of engine that may surpass the conventional type are now subject to experimentation. The water-cooled Almen barrel-type engine has reached the stage in which it can at least equal the conventional type in regard to weight, bulk, and stability and, due to inherently compact arrangement and general rigidity, it may develop into a lighter and more compact engine than any now available. In the air-cooled class, the cam engine also eliminates the conventional connecting-rod and crankshaft arrangement and has as chief advantages possibilities of reduced complication and cost rather than weight reduction. It provides perfect running-balance in the four-cylinder engines and permits smooth operation at higher outputs than was formerly possible with four cylinders. It is believed that the cam-and-roller mechanism can be produced at less cost than that of the crankshaft and connecting-rod arrangement which it replaces. The piston makes four strokes for each revolution of the main shaft, thus providing the advantage of a 2 to 1 reduction-gear without complication or increase in weight. It is still in the very early stage of development.

Only in the last year has development of inverted engines progressed to their successful operation in service airplanes. The chief advantages of this arrangement appear to be improvement in visibility forward, easier disposition of the exhaust gases, higher location of the propeller center, and

greater accessibility from the ground to the carbureter, spark-plugs, and valves.

## REDUCTION GEARS AND SUPERCHARGER DEVELOPMENT

Increased size of the engines and the higher crankshaft speeds employed rendered the introduction of reduction gears essential, and recent improvement in methods of gear manufacture has made their use attractive because present highly reliable gears add less than 0.2 lb. per hp. to the powerplant weight. Analysis of several typical aircraft reduction-gears shows tooth speeds of approximately 3500 ft. per min. accompanied by tangential loads of 2000 lb. per in. of face width. Gears combining hardness, strength and accuracy sufficient to permit operation under the foregoing severe conditions have only recently become available. A shock-absorbing coupling between the crankshaft and the driving pinion has been used to protect aircraft reduction-gears from the ill effects of engine-torque variation in most cases.

Turbine superchargers are now in service which, as a result of development since the war, are fully as reliable as other parts of an aircraft powerplant. Gear-driven supercharger-development has begun somewhat later than that for the turbine type, and has not yet resulted in a design considered sufficiently reliable for service use. The chief problem for the latter type has been to provide a satisfactory light-weight driving-train that will withstand the violent acceleration to which an aircraft engine is subject. This appears to have been overcome by reducing the inertia of the high-speed impeller to the minimum and by utilizing a flexible spring coupling between the crankshaft and the gearing. Use of the supercharger increases the height of ceiling capability of any type of airplane approximately 80 per cent, and greatly improves airplane speed and maneuverability at great altitude.

## ENGINEERING DIVISION'S ATTITUDE AND ACHIEVEMENTS

With respect to the foregoing developments, the functions of the Engineering Division are confined to basic research, development testing, the financing of experimental developments, and the supervision of experimental contracts. In mentioning Engineering Division activities, those of all contractors are included and the major part of the credit for successful accomplishment of results is accorded them. The chief task of the Division consists in seeing that the proper lines of development are followed, by giving financial encouragement to developments that appear to be desirable; thus, actual development is largely in the hands of the industry, while the determination as to what lines it shall follow is controlled mainly by the Division.

Among the outstanding achievements in which McCook Field, cooperating with the contractors, has taken the lead are: The first American engine in the 700-hp. class; the largest American water-cooled engine in use today; the lightest American water-cooled engine; the highest speed American water-cooled engine to pass an endurance test successfully; the first successful application of the inverted engine for service airplanes; the first American-built nine-cylinder radial-engines in the 150 and the 400-hp. classes; the only successful modern air-cooled V-type engine of an output suitable for service airplanes; the only air-cooled cylinders of more than 30 hp. that have proved satisfactory from the standpoints of reliability, output per unit weight, cooling, and fuel consumption; the first successful application of the rotary induction system to American radial engines; the first air-cooled engine to be equipped with a completely enclosed and thoroughly lubricated valve-gear; the largest air-cooled engine; the only successful supercharger to go into service use; all work on the application of gear-driven centrifugal-superchargers to American aircraft engines; and the development of a complete line of accessories necessary for satisfactory operation of the supercharged airplane.

<sup>1</sup> Abstract of an address at McCook Field, Dayton, Ohio, made by E. T. Jones, to representatives of the American Society of Mechanical Engineers and members of the Dayton Section. The author is chief of powerplant section of the engineering division, Air Service, McCook Field, Dayton, Ohio.

# A Possible Solution of the Headlighting Problem

By H. M. CRANE<sup>1</sup>

DETROIT SECTION PAPER

Illustrated with DIAGRAMS AND PHOTOGRAPH

## ABSTRACT

STATING that so far as the public is concerned the headlighting problem is an extremely difficult one, the author remarks on how greatly the problem is complicated by the necessity of providing satisfactory headlights on cars already in operation as well as on new cars and outlines the procedure followed by legally authorized stations in New York State regarding headlight adjustment. Problems of enforcement of headlighting regulations are discussed and considerations regarding the factors that constitute ideal headlighting standards are presented.

The method of headlighting proposed by the author is described and is illustrated by diagrams. It results from experiments made with a car having standard equipment consisting of head-lamps provided with parabolic reflectors and Bausch & Lomb lenses mounted 36 in. above the road surface and adjusted possibly to a dip of 4 in. at 25 ft. The lens in the right lamp is rotated about 9 deg. in the proper direction to lower the left end of the projected beam and to raise the right end. A separate switch permits the extinguishment of the left headlight alone. With that headlight extinguished, the regular city driving or parking-light furnishes a marker-light for the left side of the car. In conclusion, the possibility of using diffused light produced by large-diameter frosted-bulbs on cars of low price and reasonably moderate speed is suggested.

SINCE the volume of complaints is increasing daily and, as engineers, we cannot evade our share of responsibility for a condition that we all admit is thoroughly unsatisfactory, I will not apologize for bringing up for discussion at this time the question of better lighting service for our cars and our highways. I am not minimizing or criticizing the work that has been done in the past by car engineers, by engineers of lighting equipment and by specialists in illumination, generally, but I am sure that we never will arrive at a satisfactory result except by a concerted effort of all who have in any way a contributing influence. This makes it necessary to add to the previous list the builders of cars who control the quality of lighting equipment supplied and, above all, the public, who, in the long run, will get what they demand in lighting-equipment quality, but who, in any case, are responsible for seeing to it that their lighting equipment meets reasonable requirements of safety to themselves and to other drivers.

The problem, so far as the public is concerned, is an extremely difficult one. It probably is possible, under present forms of regulation, to provide fairly good driving-light with absence of glare during the first year's use of a new car. I am strongly impressed, however, by many years of driving at night that the older equipment constitutes a real problem. I think that a census of all the cars on Long Island, N. Y., that have been bought by the present owners for \$100 or less would provide some idea of the tremendous difficulties we are

facing. Many thousands of such cars are used by employees of all sorts of undertakings in going to and from work or for similar purposes. The owners of such cars certainly will not provide them with high-grade lighting-equipment unless they are forced to do so, and I am entirely satisfied that a rigid enforcement in this direction is entirely out of the question. Most of these cars are driven for short distances only, after dark, but the total number of miles for all of them is very impressive. Many of these cars, after years of neglect, have almost no driving light whatever, and therefore their owners are the most serious critics of glare from other cars.

I have just had occasion to go over the discussion at the May, 1925, meeting of the Metropolitan Section of the Society and find many arguments in it strongly favoring the Society's present specifications, the statement usually being made that they are satisfactory if properly enforced. We are now nearing the end of a year of enforcement in New York State and from personal experience I can say that the over-all improvement in conditions is practically negligible. This is partly because only a relatively small number of cars have been reached by the enforcement officers, and rarely any of the class just described; and also because the enforcement regulations are aimed primarily at the suppression of glare and have therefore resulted in practically annulling the satisfactory driving-light supposedly provided under the specifications of the Illuminating Engineering Society and those of this Society. The method of adjustment used by legally authorized stations in New York State is as follows:

The car is placed on a level floor facing a vertical wall, with its headlights at a distance of 25 ft. from the wall. The height of the headlight centers above the ground is measured and a bar on the wall is adjusted accordingly, depending upon the type of car and upon the maximum passenger-load. In average cases, this bar is placed 7 in. below the height of the headlight centers. If the headlight centers are 36 in. above the ground, which is very common, the bar is placed at 29 in. The headlights are then adjusted so that the upper cut-off of the light is below the bar. Under these conditions the cut-off point will meet the road surface at a point 129 ft. ahead of the head-lamps. For Ford, Chevrolet and other light cars, the figure given is from 8 to 9 in., which means that the cut-off point will strike the road surface at 112½ ft. or 100 ft. ahead, as the case may be.

It is futile to claim that headlights adjusted in this way give anything like a satisfactory driving-light except for slow-speed work. It is certain also that if headlights are to be adjusted in this way there is no possible use in providing more than 2000 to 3000 cp. in the most concentrated part of the beam. Proponents of the present type of regulation cannot fairly claim for it a driving light not permitted by the enforcement officers. My own opinion is that the enforcement offi-

<sup>1</sup>M.S.A.E.—Technical assistant to the president, General Motors Corporation, New York City.



FIG. 1—ILLUMINATION DIAGRAM FROM HEADLIGHTS AS ORIGINALLY OPERATED  
Light for City Driving or Parking Is Provided by Low-Candlepower Bulbs in the Main Headlight-Reflectors

cers, acting on the results of experience have been forced to the action taken to prevent highly objectionable glare produced by variations in car loading or road surface or changes in road contour. I certainly do not blame the enforcement officers for taking such action. It is a natural result of the system of regulation coupled with the excessive candlepower produced in parts of the headlight beam by many of the lenses and reflectors now being supplied on cars.

#### IDEAL HEADLIGHTING STANDARDS

In a clipping from the *Detroit Free Press* of Oct. 23, 1925, dated Grand Rapids, Mich., and giving information regarding the State uniform traffic-code conference being held at that time, I find the following: "A resolution was adopted asking the legislature to standardize headlights for motor vehicles."

Do automotive engineers feel sure that they know what this standardization ought to be and are they satisfied, if the standardization follows the lines of what has been done in the East, that the result will be satisfactory? Mark Twain once said that everybody complains about the weather but nobody does anything about it. In this case I will try to justify my critical attitude of the present situation by making what I believe are constructive suggestions, which will be the subject of an actual demonstration at this meeting so far as a proper demonstration can be carried out in the limited space available.

Before proceeding to a description of the apparatus to be demonstrated, I call to your attention one phase of regulation that especially merits discussion at this time. The lighting specifications of the Illuminating Engineering Society and those of this Society were based on the idea of producing a safe driving-light without objectionable glare and with a fixed adjustment; in other words, it was thought to be desirable, if possible, to obtain a safe driving-light without requiring either dimming or beam deflection to reduce glare when meeting an approaching car. In my own opinion, experience has shown this to be an impossible compromise; but, further than that, car users have indicated very clearly by their actions that they are not satisfied with any such arrangement. I will show you that, if we assume some action by the driver of a car resulting in the modification of light distribution from his headlights when meeting an approaching car, we will be able to give a much better driving-light coupled with a much less objection-

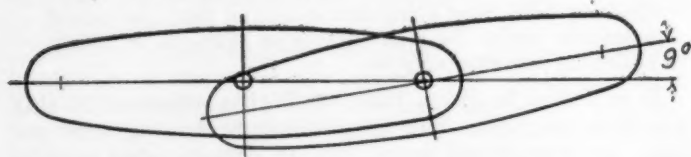


FIG. 2—LIGHT DISTRIBUTION PRODUCED BY THE REVISED ARRANGEMENT  
In This Arrangement the Lens in the Right Head-Lamp Was Rotated about 9 Deg. in the Proper Direction To Lower the Left End of the Projected Beam and To Raise the Right End. A Separate Switch Was Provided To Permit the Extinguishment of the Left Headlight Alone. With That Headlight Extinguished, the Regular City-Driving Light Furnishes a Marker-Light for the Left Side of the Car

able glare than is possible under fixed equipment based on the specifications of the Illuminating Engineering Society and those of this Society. I can say from personal experience that the public as a whole can be trusted to use equipment of this kind in a most considerate manner. I hope that it will be the sense of this meeting to declare that a system of regulation based on the foregoing theory is the correct one to encourage. I would hesitate to urge this unless I could show how the idea can be carried out at no greater cost than is now required under the simplest form of apparatus that meets existing laws and without paying a patent royalty to anyone.

#### PROPOSED HEADLIGHTING METHOD

The suggested scheme of headlighting as tested by me to date has been evolved from experimental use of standard equipment already on my car. This equipment consists of head-lamps having parabolic reflectors and equipped with Bausch & Lomb lenses. These head-lamps are mounted about 36 in. above the road surface and are adjusted at present with possibly a dip of 4 in. at 25

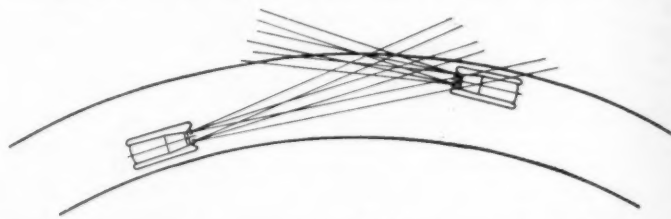


FIG. 3—DIRECTION OF LIGHT BEAMS WHEN CARS MEET ON A CURVE  
Regarding the Objectionable Effect of the Raised Beam on the Right Side When Cars Are Approaching on a Curve, No Difficulty Can Arise from the Car on the Outside of the Turn. The Light from the Car on the Inside May Reach to the Level of a Driver's Eyes But, Practically, This Occurs Only at Considerable Distances

ft. Fig. 1 indicates approximately the diagram of illumination from the headlights as originally operated. I should say at this point that light for city driving or parking is provided by low-candlepower bulbs in the main headlight-reflectors. To change this arrangement to the new system, the lens in the right head-lamp was rotated about 9 deg. in the proper direction to lower the left end of the projected beam and to raise the right end.

Fig. 2 indicates approximately the light distribution with this revised arrangement. A separate switch was then provided to permit the extinguishment of the left headlight alone. With the left headlight extinguished, the regular city driving-light furnishes a marker-light for the left side of the car. When two cars equipped with this system approach each other, the left headlight in each case is either extinguished as described or heavily dimmed, no change being made in either the intensity or the direction of the right headlight, the result being that the passing-light on the right side of the road of each car is maintained at maximum efficiency while illumination on the left side of the road is in each case furnished by the approaching car. This arrangement reduces the glaring effect at least 50 per cent, even under the best conditions, and much more than 50 per cent under conditions of rough road-surface or heavy road-crowning. It also greatly reduces the reflected glare from wet pavements, which is a serious objection to the tilting-beam type of headlight control.

I already have driven many hours after dark with this lighting arrangement, acting only as an observer, the car being driven by a chauffeur. Under these conditions I have been able to observe the light distribution closely, the visibility of various parts of the foreground and the effect on approaching cars. A very noticeable point is that the extinguishment of the left headlight

produces no observable decrease in illumination when another car is approaching; in other words, the light from this lamp under normal conditions is being thrown on a part of the road already lighted by the approaching car and gives no useful result in illumination to offset any glare produced by it. At the same time the right headlight, due to the angular position of the beam, rarely throws any blinding rays above the wheel-hub of an approaching vehicle while at the same time maintaining a long-distance beam on the right side of the road, where it is most needed. The advantage of these two points is most noticeable on heavily crowned roads, although it is present to a great degree under all conditions.

A legitimate question will be raised by those who have not tried this arrangement as to the objectionable effect of the raised beam on the right side when cars are approaching on a curve. Of course, no difficulty can arise from a car on the outside of the turn; but the light from the car on the inside can, under conceivable conditions, reach to the level of a driver's eyes. Practically, I find that this occurs only at considerable distances and when the driver who would be discommoded is looking in an entirely different direction.

Fig. 3 indicates clearly the surrounding circumstances. Of course, where turns are banked, either over the whole road-surface or due to crowning of the road, the rise of the right beam is almost entirely nullified. I am not entirely certain that the exact arrangement described, especially as to the direction of the beams, is the best one possible. It is probable that some change in light distribution from the headlights would be advantageous to take full advantage of a system that is not handicapped by the old fixed-beam arrangement. The actual arrangement is shown on the two cars on exhibition here and I will leave it to the discussion to bring out more fully the advantages and disadvantages of this arrangement as compared with other systems now in use or proposed.

The system just described is open to one objection, the necessity for some control over the direction of headlight beams of considerable power. That this control need not be nearly so accurate as is required by the old fixed-beam system is true; but, to get satisfactory results with this or any similar system, we must have full cooperation by car users, either voluntary or under the stress of rigid enforcement.

#### FROSTED BULBS

I have already stated that, in the lower-priced field, especially in the case of second-hand cars, a serious problem exists for any officers attempting to enforce a headlight law. It is for this reason that I have suggested the possibility of using diffused light produced by large-diameter frosted-bulbs on cars of low price and presumably moderate speed. This is the only foolproof system of which I know regarding glare and, if set up with an arrangement to dim the left headlight, can be made entirely satisfactory in this respect. The driving light for purposes of passing leaves something to be desired as compared to a really high-grade equipment installed according to the first plan that I outlined in this paper. It is much better, however, than the driving light produced by heavily tilted reflectors in the present system. Headlights having the frosted-bulb equipment will be exhibited here for inspection and criticism. I believe that the permissive use of such equipment on

low-priced cars under restrictions as to candlepower and bulb diameter would find complete justification in actual service.

Regarding the bulb equipment for headlights of the now conventional construction, I make the suggestion that these bulbs be frosted over that part of the surface through which the direct rays from the filament pass out through the headlight glass. In many lenses today, several filaments appear when looking at the headlight from one side and produce a type of glare that has some irritating effect if only on the mind of the observer. I am informed that if the frosting can be done on the inside of the bulb, it will be easier to produce either reflectors or lenses without certain undesirable stray rays.

#### THE DISCUSSION

C. E. GODLEY<sup>2</sup>:—We conducted experiments about 10 years ago, trying different kinds of beam ahead and in different directions. We would have adopted this method at that time, but we thought it could not be made to operate successfully, although perhaps it can be made to do so now. We know it to be a good thing to install on old cars that are still operating; it would improve conditions in that way, but I believe it is not suitable for new equipment.

J. H. HUNT<sup>3</sup>:—Mr. Godley has mentioned that he tried this headlighting method some years ago. I will not claim to be the first one to try it, but I tried a similar arrangement almost 10 years ago. I find that, as Mr. Crane has it worked out, he has made a real improvement. Before the Ohio law required lenses and when the authorities first attempted to compel dimming, I tried pointing the light of a lens-equipped lamp outward 1 deg. and low enough so that there was no question about glare, and provided for switching from the small auxiliary bulb mounted in the left headlamp to the main bulb in the same lamp, without affecting the right headlamp. I obtained very satisfactory results. In practically every case, the approaching driver dimmed his lights but, if he did not, I usually was able to induce him to dim because I had no lens on the left headlamp. To the extent that I had no lens on the left headlamp, this does not apply to Mr. Crane's proposal; also, the axis of the right beam was not rotated. I tried Mr. Crane's arrangement recently and my experience confirms Mr. Crane's. In driving around Detroit, I had the general experience that the drivers I met would dim and, even if I drove toward an approaching driver for ½ mile when no one else was on the road, with the left head-light dimmed, the approaching driver would dim when he was approximately 600 ft. distant. I did not adjust the lamps exactly as Mr. Crane has suggested. I left the upper right corner of the beam on the right headlamp in the normal position and simply twisted the whole beam around.

One of the things that makes this lamp problem so difficult is that everyone thinks he knows what he wants and it is almost impossible to convince him that he may be mistaken. I was very well satisfied with the result I obtained; but there may be others who will not be satisfied. In connection with the regulations and the difficulties of the enforcement problem, one of the reasons for this is that drivers think they know what they want and then proceed to get it. To get a good driving-light, a driver is likely to point the lamps too far up; but, with the proposed scheme, he has a fairly decent driving-light from the right headlamp when meeting another car, and he will be much more inclined to dim his lights than he seems to be at present.

<sup>2</sup> M.S.A.E.—Chief engineer, Edmunds & Jones Corporation, Detroit.

<sup>3</sup> M.S.A.E.—Head of electrical division, General Motors Corporation Research Laboratories, Detroit.

I wish to emphasize one point that Mr. Crane makes. I, also, believe that the big problem ahead of us is whether we are to have a device to be controlled by the driver when we meet another car. That is the fundamental point of this discussion. We already require it in Michigan, even if a driver has headlights to conform to the Illuminating Engineering Society's specifications. So far as Ohio and Indiana are concerned, we are not putting any greater burden on the driver than they do. If we admit that the driver can do something, we might go a step farther and change the beam pattern of the left headlight so as to increase the light from it down the center of the road and thus compensate for taking away the light that we no longer get from the right headlamp, due to having its beam set at an angle.

I. H. GORE<sup>1</sup>:—The old cars probably need the headlighting method under discussion, for eliminating glare without destroying light, about as much as the new cars. In 1867, the first patent was allowed to a Mr. Kirby on "controllable light"; and so we have done nothing to change headlight demands up to now, but are manufacturing a practical unit which is in demand. The device has a 21-cp. unit that fits into the headlamp, using the same parabolic type of reflector as is used now in the ordinary headlight. With this device in the "up" position, which is the legal or normal position, the projection of light is from 400 to 600 ft. In the tilted, or "down" position, the light begins 25 ft. in front of the car and varies from 75 to 100 ft. in front of the car, according to kind of lens used, with no glare. Those two points comply with claims made for inventions in 1398 patents, but never could be used commercially until the device I refer to was developed. This device accomplishes just what the mechanical Cadillac and Lincoln headlights have accomplished in the past but does it electrically.

R. N. FALGE<sup>2</sup>:—The specification sponsored by the Illuminating Engineering Society and by this Society was offered as one of several elements required in the improvement of headlighting conditions. Its sponsors realized from the start what was demanded of the industry, the trade, the State, and the motorist to make it effective. Experience merely has emphasized the importance of these other elements and, in general how seriously they have been neglected. Implied in this system were proper mechanical construction and mounting of headlamps, good optical design and adequate facilities for servicing.

The optical design of equipments has been well ahead of the mechanical construction and the organization for servicing needed to make it effective in practice. Mr. Crane has stated that the limited enforcement-efforts over a period of a few months in one large State have resulted in no considerable improvement, but is it reasonable to expect the State to accomplish all of its part in a few months when the industry, in all these years, on a large proportion of the cars, has not provided accurate headlamps constructed and mounted so that they will stay put? The increasing attention to headlamp construction accelerated in the last year by the decision of the Eastern Conference of Motor Vehicle Administrators to approve complete headlamps only, rather than a part of the optical system, promises radical improvement in this respect. Then some incentive for the State and the motorist to cooperate will be offered.

Is it not an anomaly that the automotive industry and

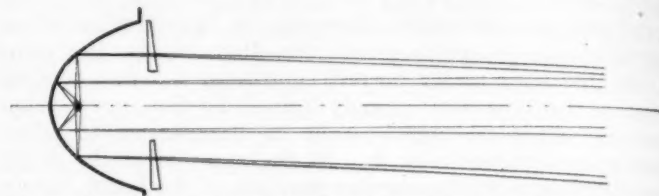


FIG. 4—OBTAINING BY DESIGN THE VARIATIONS DUE TO PRODUCTION FORMING THE UPPER PART OF THE BEAM WITH LIGHT FROM THE MIDDLE TRANSVERSE-ZONE OF THE REFLECTOR MAKES THE BEAM LESS SENSITIVE TO VARIATIONS IN LIGHT-SOURCE POSITIONING. INSTEAD OF ACCOMPLISHING THIS WITH BENDING PRISMS, AS ILLUSTRATED, THE SAME RESULT CAN BE OBTAINED BY MODIFYING THE REFLECTOR CONTOUR SO AS TO DROP THE UPPER AND THE LOWER SECTIONS

trade, having provided most adequately for the servicing of all parts of the car, should so long have left it to the State to organize facilities for servicing the headlights that are a major factor in the safety and convenience of driving; in fact, in many cases that determine the extent of use of the car? When the industry with its improving equipment has met this neglected responsibility as well, the basis requisite for general compliance with regulations will be established.

In optical design opportunity is also afforded for more general application of principles that make headlamps relatively insensitive to variations due to commercial production. Thus, when the upper part of the beam is formed with the light from the middle transverse-zone of the reflector, as shown in Fig. 4, the upper level of the beam can be maintained over a comparatively wide range of filament positioning ahead and back of focus. This practice also keeps the highest intensity near the top and maintains a sharp cut-off, despite small variations in filament location above and below the focus. Such variations as do occur in the beam are confined largely to the lower part where they are of relatively little consequence. Further improvement results from the addition of shallow cross-fluting or otherwise providing for increased overlapping of the horizontal bands of light.

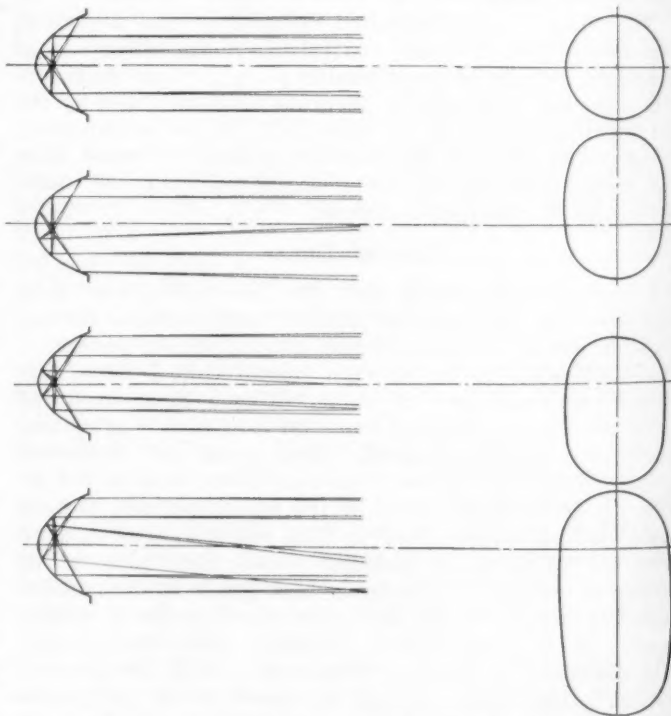


FIG. 5—UTILIZATION OF SIMPLE OPTICAL PRINCIPLES THE FOUR VIEWS ILLUSTRATE LIGHT DISTRIBUTION IN BEAMS FROM A PARABOLIC REFLECTOR WITH THE LAMP FILAMENT AT THE FOCUS, AS IN THE TOP VIEW; WITH THE LAMP FILAMENT BELOW THE FOCUS, AS IN THE UPPER-CENTRAL VIEW; WITH THE LAMP FILAMENT ABOVE THE FOCUS, AS IN THE LOWER-CENTRAL VIEW; AND WITH THE LAMP FILAMENT FARTHER ABOVE THE FOCUS, AS IN THE BOTTOM VIEW

<sup>1</sup> Director of sales, Yeager Tilt-O-Lite Co., Columbus, Ohio.

<sup>2</sup> M.S.A.E.—Engineering department, in charge of automotive lighting, National Lamp Works of the General Electric Co., Nela Park, Cleveland.

A third principle is that of bending the light from the extreme upper section of the reflector well down toward the bottom of the beam. The part of the reflector most difficult to control in production is the outer edge that tends to draw away from the parabolic contour and thus to direct too much light upward. Production variations occur also near the center of the reflector and can be compensated for by bending these rays downward or diffusing them.

Mr. Crane has emphasized the long recognized need for modification of the fixed-beam system in meeting other cars under many conditions of service. The limitations of the fixed-beam head-lamp have become especially prominent with the effort of some States to minimize the chances of glare by requiring a loading allowance that tilts all headlight beams so far down as to create a much greater hazard due to decreased distance of road illuminated. Safety requires the higher aiming of the main beam to give the results contemplated in the specifications of the Illuminating Engineering Society and this Society.

The dual system of headlighting has the strong endorsement of the Illuminating Engineering Society. Relatively expensive means of securing such modification of the headlights have had a limited use for some years.

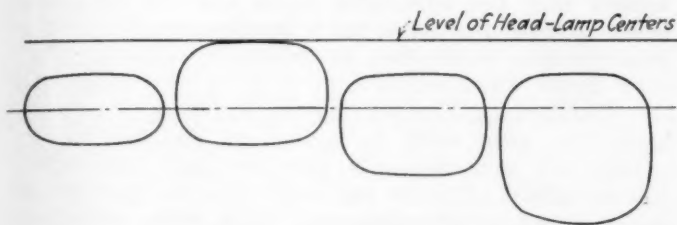


FIG. 6—BEAMS OF FIG. 5 WHEN SPREAD BY A FLUTED LENS  
Light Patterns on a Vertical Surface Are Shown. In a Head-Lamp Equipped with a Fluted Cover-Glass and Aimed So As To Bring the Top of the Higher Beam, in the Left-Central View, from the Lower of the Two Filaments, to the Level of the Head-Lamp Centers, the Relative Directions and Shapes of Beam from the Second Filament in Any One of the Other Three Positions Would Appear As in the Left-Hand, the Right-Central and the Extreme-Right Views. The Degree of Tilt between the Tops of the Two Beams Can Be Controlled within Wide Limits by Varying the Displacement of the Lower Filament

Now there is promise of very general adoption of the practice. Mr. Crane suggests the dimming of one of two dissimilar head-lamps. The practice is growing, especially on cars already in service, of adding an auxiliary driving-light as the alternative. This year has seen the very rapid adoption for initial installation of an inexpensive and positive method of obtaining the desired beam modification by the simple optical means of two filaments in the bulb, with suitably coordinated lens and reflector elements:

The simple optical principles that are utilized to produce this result are illustrated in Fig. 5. When the light source is at the focus of a parabolic reflector, the rays are reflected into a narrow beam which in falling on a screen at right angles to the beam, produce the round spot of light shown in the view at the top. If the filament is below the focus, as in the upper central view, the spot of light is extended upward into an oval. However, if the filament is above the focus, as in the lower central view, the extension is downward, but the level of the top of the beam remains unaltered. As the filament is moved farther above the focus, the distorted beam becomes deeper, as in the bottom view, the top of the beam still remaining at the same level.

Thus it is seen that a bulb provided with two filaments, one directly above the other, makes possible a controllable beam depressible at the will of the driver. In a head-

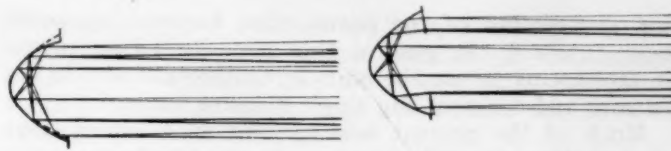


FIG. 7—MOST DESIRABLE FORM OF CONTROLLABLE BEAM  
Excellent Light-Distribution and the Simplest Adjustment Result When the Reflector Surface or Lens, or Both, Are Modified for Filaments Placed As in the Top View of Fig. 5, Shown at the Left; and Placed As in the Bottom View of Fig. 5, Shown at the Right

lamp equipped with a fluted cover-glass and aimed so as to bring the top of the higher beam, in the left-central view in Fig. 6, from the lower of the two filaments, to the level of the head-lamp centers, the relative directions and shapes of beams from the second filament in any one of the other three positions would appear as in the extreme left, the right-central and the extreme right views. The degree of tilt between the tops of the two beams can be controlled within wide limits by varying the displacement of the lower filament. The desirable 2 or 3-deg. tilt results with the ordinary parabolic reflector and vertically fluted cover-glass when the lower filament is approximately 1/16 in. below the focus and the upper filament is at or above the focus. Whether the upper filament is at the focus or slightly above, makes no material difference in the tilt between the tops of the beams, but a more satisfactory driving-light is obtained when the upper filament is at least 1/16 in. above the focus.

Although the tilt between the beams is not materially affected by small variations in the distance of the upper filament above the focus of the reflector, it is sensitive to the positioning of the lower filament. To assure proper positioning of the lower filament with respect to the focus of the reflector it is necessary, in the case of the unmodified parabolic reflector and a lens having only vertical spreading-flutes, to provide a focusing screw for vertical adjustment to compensate for variations in bulbs and in head-lamp assembly. Obviously, the focus-

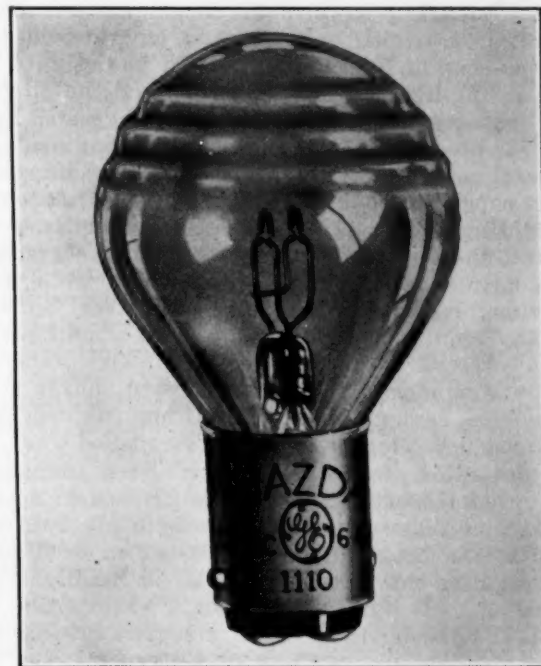


FIG. 8—THE TWO-FILAMENT BULB FOR DEPRESSIBLE-BEAM HEAD-LAMPS

Both Filaments Are of 21 Cp., and Are Set 9/64 In. Apart. They Are Spaced Equally Above and Below the Bulb Axis

ing and aiming of the beams then becomes somewhat more involved. In general, this same limitation applies in attempting to use the lamp in equipments now in use on cars and designed for single-filament lamps.

Much of the present headlighting is, however, done with another class of equipment in which reflectors with modified surfaces, or lenses with bending prisms, or a combination of both, are employed. These equipments can be designed to give the most desirable form of controllable beam, and without adding any vertical adjustment or complicating the procedure followed in focusing ordinary fixed-beam head-lamps. The principle employed here is that of placing one filament at the focus, as in the top view in Fig. 5, and the other filament above the focus, and modifying the contour of the reflector or the design of the lens, or both, to provide the desired tilt between the beams, as indicated in Fig. 7. It so happens that the light which remains just below the headlamp-center level when the offset filament is turned-on in ordinary equipment, comes from the upper and the lower zones of the reflector. Therefore, the top of the depressed beam can be brought down the desired 2 or 3 deg. by placing prisms on the lens over the upper and the lower portions of the reflector, or by modifying the reflector, or by a combination of both.

Thus, the improved optical features advocated in the paper are incorporated. The two-filament equipments have also all been developed under the present Eastern Conference regulations covering the design and construction of the complete head-lamp.

In adapting cars already equipped with fixed-beam head-lamps for the later practice, to provide the extra vertical focusing adjustment in the old lamps, is not easy. The easiest way is to replace the lenses or reflectors with new elements designed especially for use with the two-filament lamp. The alternative practice has already been mentioned, that of adding a separate auxiliary driving-lamp, or lamps, attached to the car in a fixed position with the top of the beam directed 2 or 3 deg. below that of the headlight beam and connected so that it is switched-on when the headlights are dimmed. Most of those available in the past have provided only a narrow cone of light. They should be designed so as to spread the light out over the road and the ditch.

The inadequacy of the frosted bulb, suggested by Mr. Crane for headlighting on cheaper cars, was made clear by several contributors to the discussion of Mr. Crane's earlier paper, *Fundamental Principles of Automobile Headlighting*.<sup>\*</sup> This system directs several times more glare into the approaching driver's eyes than systematic studies have shown is tolerable for safety, while, at the same time, reducing road illumination far below the minimum requirement for many road conditions and creating especial hazard in haze and in fog. There appears to be no more place for the frosted bulb in a dual-beam system, as suggested by Mr. Crane; its deficiencies merely would be emphasized when so applied.

In connection with Mr. Crane's last suggestion, namely, that the end of the bulb be frosted to do away with multiple filament-images sometimes observed when looking at the headlight, Fig. 8 is shown to illustrate the corrugation now incorporated in all headlight bulbs to accomplish a similar purpose. Frosting the bulb, even on the inside, is likely to make the source more objectionable, rather than less so.

L. C. PORTER<sup>†</sup>:—Mr. Hunt spoke of using a symmetri-

cal beam. When we want to keep the light out of the eyes in the upper-left quadrant, I see no reason that we should have a symmetrical beam to do it. I agree that the situation is very bad. Mr. Crane stated that the situation is fairly good on new cars but that most of the trouble comes on the old cars. That is because the equipment does not stay in adjustment. Engine builders would not think of turning out an engine that within a few days or weeks or months would not run, but headlight manufacturers seem to have no hesitancy in making and selling headlights that, within a short time, get out of order and will not work. One of the greatest improvements that can be made by the automobile builders is to install substantial equipment for headlights. The average driver would pay \$5 more for a car with good headlights.

The Bausch & Lomb lens that was advocated, with its light-beam tilted at 9 deg., has a spread of 9½ ft. horizontally and 51 in. vertically. This means that with a 9-deg. tilt, the top of the beam is 5 ft. above the center of the road and only 18 in. above at the lower end of the beam. Perhaps that is enough to reduce the glare somewhat when the equipment is nicely adjusted, but what will happen with lamps that are away out of adjustment with the beams pointed up still higher? I believe that the adjustable beam and the depressible beam are bound to come, but I cannot conceive of a fixed beam meeting to the best advantage the different conditions under which we have to drive. I also believe that the Illuminating Engineering Society and this Society have done good work in laying out specifications for beams that give not only safe but very satisfactory driving-lights. I think the best thing to do is to get behind these specifications and build better equipment that will comply with them.

H. M. CRANE:—After having those who have discussed the paper express opinions that I am not the originator of this idea and take the idea all apart, there appears to be no credit for anybody to have thought of all this. However, I wish that any who feel that headlighting conditions are good in New York State would take a Ford car and adjust its head-lamps according to the New York State legal-requirements. Many Ford cars are driven when only two people occupy them, although they are adjusted for five passengers, and this affects the elevation of the beams. I already have called attention to the fact that the beam of highest power hits the ground 112 ft. ahead of the car. It is futile to try to drive with a beam that does not light the road more than 15 ft. ahead of the car. All that such beams do is to create a bright spot right in front of the car. If anyone does not believe that, let him adjust the lights that way and try it. When you have that kind of enforcement here you may begin to realize why I talk about adjusting the beam. Why talk about tilting the light on the right side down when you do not need to do so to satisfy the approaching driver? I had my car adjusted at a service-station and then drove it. The light was all right for speeds up to about 30 m.p.h. and no more. I was cursed because I did not dim my headlights. Since I shifted over to this other arrangement I have headlights that give a good driving-light, and no one has ever complained about them.

At the time frosted bulbs were used in the head-lamps of Ford cars the current was supplied by the flywheel generator and to meet one of them on a hill at low speed, with its head-lamps lighted, was some experience. I think that the Ford engineers have gone much too far in increasing the intensity of the penetrating beam when

<sup>\*</sup>See THE JOURNAL, December, 1925, p. 559.

<sup>†</sup>M.S.A.E.—Engineer in charge of special development, Edison Lamp Works of the General Electric Co., Harrison, N. J.

it cannot be used on the road without discommoding other drivers. As to the glare on approaching a car with one headlight dimmed, the fact that the car passes you nearly 3 ft. farther away from the light has considerable to do with it. Of course, this idea came to me as simply a way to avoid making a number of customers buy spot-lights for their cars. I find that this is common practice in Detroit, and I feel that it is no credit to the engineers of the car builders. If the car builder believes that the public wants this kind of light, why does he not provide it? The same applies to the tilting-beam equipment. Of course, it is a fairly high-priced article to put on a low-priced car, but anything that costs over 20 cents is a fairly expensive article for a low-priced car. Of course, if you provide reflectors or lenses or both, properly designed for service, you can improve conditions materially. I used the original Bausch & Lomb lens; but, due to the Illuminating Engineering Society's specifications, it is not allowed now because, in the upper-left corner, when tilted up a little, glare is produced.

If tilted down by rotating the lens, approximately the 800 cp. that is required by the Illuminating Engineering Society is available. This old type of lens, due to the vertical spread of beam, does not produce the so-called "hollow spots" on the road.

At a meeting some time ago, I told the petroleum interests that they were putting out a gasoline, 10 per cent of the constituents of which might as well be poured out on the ground. I caused considerable argument. I was wrong in my statement and I know it now, but what I accomplished in making that statement has been of great advantage to the automotive industry, an amount of advantage that it is difficult to realize today. I mean that I helped to start something in the petroleum business that would tend to adapt the fuel better to the engines, instead of requiring us, as engineers, to build engines to run on unsuitable fuel. If I have succeeded in stirring-up any thought on the subject of headlights, so that we get real improvement on the road, I shall be satisfied.

## TRUCK LIGHTING WITHOUT STORAGE-BATTERY<sup>1</sup>

TRUCK lighting differs from passenger-car lighting in several respects: (a) the speed of a truck is usually only about one-half that of a passenger car and (b) truck lights should have a wider spread and more side light, but do not require a beam reaching so far ahead. This can often be accomplished by mounting the lights on the dash and giving them considerable tilt so that they will not glare. In this position they are less liable to damage and are less subject to shock than when mounted in front of the radiator.

Lights on passenger cars are used almost daily but those on trucks may not be used for months, during which time parts of the lighting system may get out of order and this condition may not be apparent to the driver because of the lack of a starter to call attention to the condition of the electrical equipment. Truck lighting-equipment should be designed so that it will not deteriorate when not in use. One of the chief duties of an inspector of electrically equipped Army trucks is to keep the electrical equipment in order.

Passenger-car vibration is slight when compared to that of a truck. An empty truck, rattling over a water-washed macadamized road, is no place for batteries and delicate electrical apparatus; and vibration is the chief reason for the growing popularity of electric lighting without the use of storage-batteries. Although batteries have been greatly improved, they are still the major item of expense in the up-keep of truck lighting-systems that require their use. In this connection mention might be made of the nickel-iron-alkali type of storage battery, which has long life under severe vibration but unfortunately cannot be charged by the ordinary lighting generator on the vehicle.

Vibration also has a very bad effect on the lamps and wiring; it cannot, therefore, be too strongly urged that all wires should be well secured and all connections soldered. Even then the lamp connections may give trouble. The wires should be supported so that they will press toward the connections instead of pulling away from them and the soldered tips should be secured as firmly as possible with the poor undersize screws furnished.

The first objection offered to eliminating the storage-battery is, "What will you do for parking-lights while the engine is stopped?" Some States require parking lights. The Pennsylvania law is representative of the better class and requires a 2-cp. light showing white toward the front and red toward the rear. A light of this kind, or the tail-

light required by the California law, uses less than 0.5 amp. and, in ordinary service, the small 60-amp.-hr. lighting battery will last 2 or 3 months without recharging. The California law is very liberal in this regard for it allows parking without lights in business and residential districts when substantial objects are visible for 200 ft. Practically all long truck stops are made under these conditions and during short stops the engine is seldom shut off.

Considering the difficulty that is experienced in keeping truck tail-lights, whether gas, oil or electric, in good condition, it seems wise to add or substitute a reflex-mirror button of the type legalized for bicycles. These never go out and are excellent devices for preventing collisions.

The conventional lighting-system using batteries requires, in addition to a direct-current generator, a cut-out, a regulator, an ammeter, a switch and a fuse. The generator that we have developed produces an alternating current, requires no battery and has not cut-out, regulator, ammeter, switch, or fuse. In the generator itself, many of the parts essential to a direct-current generator are omitted. This generator has permanent field-magnets and no field-windings. It is of the inductor type, having no rotating armature-windings. The only windings are two stationary armature-coils. There are no slip-rings, no commutators, no brushes, no moving contacts, no moving wires, no screws that cannot be reached from the outside, and no screws or rivets to come loose and get into the rotating parts. But it has two things not found in an ordinary generator.

The first is a clutch control. This could be incorporated in any generator operating without a storage-battery and is a big factor in increasing the life of the generator, for no wear of the rotating parts occurs, unless the lights are used. The second feature is the use of two gear-driven rotors; two independent generators are thus combined into one series magnetic-field. The truck is wired with two circuits, each supplied by one of the generators; and damage to one circuit does not affect the other. In other words, if one headlight should become jammed and the wires short-circuited, the other light would continue to burn.

The function of the rotors is to direct the flux from the permanent magnets through the coils, first in one direction, then in the other. This is equivalent to rotating the coil in the magnetic field, as is the case with conventional generator-armatures. Changing the direction and intensity of the flux through the coil induces an alternating electric-current having four alternations, or two cycles, per revolution of the rotor. One end of each coil is grounded and the other is attached directly to the terminal.

<sup>1</sup> Abstract of a paper presented by G. B. Ridley at the monthly meeting of the Northern California Section held at San Francisco on Jan. 26. Mr. Ridley is the engineer in charge of design and production, Harris Electric Co., San Francisco.

# Proposed Constitutional Amendment

AT the Annual Meeting held in Detroit last January an amendment to the Constitution of the Society was presented by J. F. Winchester. This relates to the officers of the Society and if adopted would substitute a second vice-presidency representing operation and maintenance for the second vice-presidency representing stationary internal-combustion engineering.

In compliance with the constitutional provision the proposed amendment has been submitted to each voting member of the Society and will be discussed at the Semi-Annual Meeting that is to be held at French Lick Springs, Ind., next month. After discussion and final amendment at that meeting the amendment will be submitted by letter ballot on adoption to all members entitled to vote provided 20 votes are cast in favor of such submission.

The paragraph of the Constitution that it is proposed shall be amended is given below, the matter that would be omitted if the proposed amendment is adopted being printed in brackets [ ] with the new phrase that would be substituted in italics.

C 29 The affairs of the Society shall be managed by a board of fifteen directors chosen from among its Members or Honorary Members, which shall be styled "The Council". The Council shall consist of the President, the First Vice-President and five Second Vice-Presidents representing motor-car, aviation, tractor, marine, and [stationary internal-combustion] *operation and maintenance* engineering respectively, six Councilors, the Treasurer, and the surviving Past-President who last held office. Five members of the Council shall constitute a quorum for the transaction of business. The Secretary may take part in the deliberations of the Council, but shall not have a vote therein. The Chairman of the Finance Committee and the Chairman of the Standards Committee may attend the meetings of the Council and take part in the discussion of questions affecting their Committees, but shall not have a vote.

The amendment was not discussed at the business session in Detroit, but a number of letters commenting on the amendment have subsequently been received. For the information of the members the remarks of Mr. Winchester in proposing the amendment are given below together with pertinent extracts from the letters.

## PRESENTATION AT THE 1926 ANNUAL MEETING

J. F. WINCHESTER:—During the last year there has been some discussion by a group of men within the Society who have felt that they would like to be represented by a vice-presidency. This group of men consists largely of those who are in the operating and maintenance end of the business. During this period of time the question has been discussed also as to the advisability of discontinuing the vice-presidency representing stationary internal-combustion engineering.

As a result of this discussion, it is my understanding that it has been practically agreed that the group within the industry representing the stationary internal-combustion engineering end has been very inactive. The vice-president representing that group in a letter recently stated, I believe, that he would advise the discontinuance of that vice-presidency.

Accordingly, I would like to propose that paragraph 29 of the Constitution of the Society be amended by changing in line six thereof the words "stationary internal-combustion" to the words "operation and maintenance". That would substitute just those words in place of "stationary internal-combustion".

The effect of this would be to substitute for the Second Vice-President representing stationary internal-combustion

engineering a Second Vice-President representing operation and maintenance engineering.

[This proposal was duly seconded]

## WRITTEN COMMENTS ON AMENDMENT

B. B. BACHMAN:—As I see the matter, when the Society of Automotive Engineers was created by merging with the Society of Automobile Engineers various other automotive engineering societies, it was felt that the creation of a vice-presidency to represent each of the constituent elements was desirable.

So far as my memory serves me, there has never been any class consciousness developed which required the services of a special representative in the Council. While some of the gentlemen who have served as Vice-Presidents under this provision have rendered excellent service to the Society, their services have been as members of the Society rather than as members of a special group.

Under these circumstances, a question arises in my mind whether the general arrangement of vice-presidential representation has not outlived its usefulness; and with the thought that it has, it seems to me that, instead of modifying the present provision, an intensive study of the subject should be made to determine whether a complete revision of the whole scheme might be desirable.

Therefore, while I am not opposed to operation and maintenance being dignified, if it is so considered, with special representation on the Council, I do feel that this step is liable to lead to successive patchings of this particular Constitutional provision, which in time will make necessary a complete overhauling of the subject. I, therefore, believe that it would be the part of wisdom to take time by the forelock and do this now instead of later, when matters probably will have become more complicated.

EUGENE BOUTON:—The most outstanding feature of this amendment is its absence of anything pertaining to production. It is my opinion that to the words "operation and maintenance" "production" should have been added, making it read "operation, maintenance and production engineering respectively."

Probably the production or manufacturing phase was omitted from this amendment for certain reasons. On the whole the proposed amendment is very good and should be adopted, but it should also recognize the fact that production and manufacturing play as important a part in the automotive industry as engineering and should be included in all Society transactions.

ARCHIBALD BLACK:—I cannot see the practicability of the new arrangement as it does not provide adequate representation to the various interests. On the manufacturing side we have (a) motor car; (b) aviation, which presumably includes also airships although it says the reverse; (c) tractor; (d) marine; and (e) stationary engines. These are reasonably good divisions, although open to some minor improvement.

If we are to go into the operation and maintenance side, we shall require more than one division there also. While we might combine to some extent, it seems utterly impracticable to group all operation and maintenance under one head. For example, how could we expect the motor-truck operator to represent (a) airplane maintenance and (b) airship operation?

I have been hammering to some extent upon the distinctions between manufacturing and operating in the aircraft business. Yet these two phases would mix better than the conglomeration that the proposed "operation and maintenance" vice-president would be expected to represent!

H. C. DICKINSON:—The underlying thought has been that the present arrangement of vice-presidents no longer represents practically the present status of activities in automo-

tive lines and that it might be desirable to make some changes which would bring the organization of the Society more in line with the actual organization of engineering in the industry.

Whether there is in fact a separate stationary-engine industry is a very pertinent question and one that can almost be answered in the negative. So far as the relation of the Society to the Diesel industry is concerned, I cannot avoid the feeling that it is hardly desirable for the Society to attempt to cover the field of stationary or heavy marine Diesel engines. The type of engineering and therefore the type of engineer engaged in this work and the general problems met with seem to me so far removed from those of automotive engineering in its generally accepted sense that a combination of the two would not be particularly useful even if such a combination could be brought about.

The suggestion of a Tractor and Engine Division seems to me worth careful consideration. On the other hand, it seems to me that there are at least three rather distinct and important growing fields which involve, primarily, automotive engineering and which might be given consideration with a view to covering them more adequately in the Society's organization. These are production engineering, service engineering and highway transportation.

As for production engineering, it seems very probable that this is covered sufficiently well under the existing heads of motor-car, tractor, aeronautic, and marine engineering, although it might be worthwhile to study the question whether the distinctive problems of both engineering and standardization in the production field are not of sufficient importance to warrant separate representation on the Council.

With reference to service engineering, the situation is, of course, much the same as that expressed above.

As for highway transportation, here is a comparatively new field that will absorb an increasing number of automotive engineers and require an increasing amount of engineering knowledge and development both in engineering proper and in standardization of a kind somewhat different from the standardization in production. I believe that the subject of highway-transport engineering might well be given careful thought as to the desirability of having a separate representative on the Council.

C. F. SCOTT:—It is my own belief that the Society's obligations to the National Gas Engine Association and the Gas Engine & Farm Power Association are not neglected by the proposed change. It seems to me that we have a duty in the industry in fostering standardization and carrying out such other activities as is proper for an engineering organization, with respect to the products of the several manufacturers which were in the stationary gas-engine field. However, it is questionable whether the setting-up of a vice-presidency for this purpose is necessary, in view of the state of the stationary gas-engine industry itself and particularly in view of the rapid changes that are coming about, resulting from the growth of other types of engine. Circumstances change with the times, and in my opinion, the needs of the industry today go much further than the type of farm engine which was dominant at the time this vice-presidency was instituted.

We may eventually cover the field of Diesel engines, in all their applications, but we are not organized to do so now. This side of the situation, as well as that of making provision for another vice-presidency to represent maintenance, is the problem before us.

Whether the new division of the Society mentioned by Dr. Dickinson should cover production engineering, service engineering, highway transport, or all three is a matter which I do not feel personally qualified to comment upon except in a general way. It does seem to me that a logical way to view the matter is along the lines of the application of automotive equipment rather than the particular divisions within any one application.

Thus passenger transport by automobile is a distinct field. This involves design engineering, production engineering and service engineering. These to my mind are the three logical subdivisions of the problem as a whole.

Highway transport for the movement of goods, as distinguished from the movement of passengers is a distinct field of itself, and involves the design, production, and servicing of motor trucks.

We have not found it practicable to draw a sharp line of demarcation, between passenger-car design-engineering and motor-truck design-engineering or between the production engineering involved in both of these services. Frequently they are done by the same organization and occasionally by the same men.

Aviation is, however, sufficiently distinctive to have a place by itself. So has marine transport by internal-combustion engine.

The farm tractor has its own field which, of course, has now been broadened by the use of a tractor for other purposes than farming.

The motorcoach is a form of highway transport applied to passenger-car engineering, with some of the points common to passenger cars and some of the points common to motor trucks.

Rail-cars have come into consideration from time to time, and yet with the possible development of the Diesel engine, we have two elements that appear to be foreign to our organization records, first the Diesel engine itself and secondly the rail transportation.

When it comes to stationary-engine work I think it is impossible for us any longer to hold to the view that there is a stationary-engine industry represented by the small gasoline-engine builder, which is separate and distinct from the stationary-engine industry represented by the Diesel engine. Such a line, it seems to me, is illogical and cannot be sustained. The stationary-engine industry certainly is drawing more in the direction of Diesel engines, and if as Dr. Dickinson says our Society cannot logically go into this field, and I think he is right, then I think that, with equal logic, we cannot maintain a separate department for the small stationary-engine.

We have given some attention to isolated lighting-plants, which seems to me an encumbrance that does not properly belong in our automotive group. In the first place, it is not automotive. In the second place, it is largely a form of electrical-energy generation that, in the absence of more convenient forms of prime-movers, happens to use a gasoline engine. Yet, if we should cover the field of gasoline-type engines for small generators, it is hard to draw the conclusion that we can logically refuse to cover the field of generators driven by internal-combustion engines of larger size, and, if in the larger sizes, it is more economical to use the Diesel cycle than the Otto cycle, we have an arbitrary rather than a logical dividing-line. Of course, it is hopeless to try to organize anything like an engineering society on a purely logical basis, just as it is difficult to organize any other structure on a logical basis. For example, the whole system of railroad freight-rates in this Country has been a process of evolution and discrepancies in rates, which are totally illogical, have been repeatedly sustained by the Interstate Commerce Commission, on the ground that what is wanted is not something that is scientific, but something that tends to keep business everywhere throughout the Country occupied.

I am disposed to think that the best plan for the future would be for the Council to appoint a special committee to review the scope of the Society's activities in the light of the present-day demands of the industry and the related industries and to determine first what our scope should be for the present and, second, how we should be thus organized to cover the field to which it shall be determined we should limit ourselves.

J. F. WINCHESTER:—The Society has over a period of time accepted members from both the service and the operation ends of the automobile industry. This has been done at such a date that this group of men represent a very considerable number as compared with some other lines of interest that are represented by vice-presidencies.

The amendment was not presented until a recommendation had been made by Vice-President Scott that the vice-presidency representing stationary internal-combustion engi-

neering be discontinued. Feeling that it was the desire of the membership to continue along the lines of having five second vice-presidents, I took the opportunity to present the amendment.

The presentation of this amendment is not a new thought, as can be borne out by the words of Past-President Manly, who in 1919 stated the following, and other similar, thoughts in an address to the Society:

The work of the automotive engineer is not finished, but merely begun, when the machines are designed and built, whether they be motor trucks, tractors, aircraft, or other vehicles. There is more need today for real engineering work in connection with the planning and organization of the operating end of automotive vehicles and machines than there is in connection with the design and construction of them, just as there are more engineers engaged in the operation and maintenance end of railroads than are engaged in the design and construction of locomotives and railroad cars.

In the subdivision of automotive engineering work having to do with motor trucks, the real work of the engineer has hardly as yet begun. True it is that motor trucks are being sold and are daily hauling thousands of tons of merchandise and general freight, but the careful study and collection of data for accurately predetermining the best operating equipment, organization and personnel to meet given conditions at a definitely predetermined cost has hardly been started.

This single phase of automotive engineering presents more problems for the engineer to solve than would be needed if all our records and data in railroad-transportation engineering were suddenly swept away and it became necessary to re-establish such data immediately for the determination of proper freight rates.

Similarly, in that newest of the branches of automotive engineering, which is just now in its beginning, but which is destined to grow to be one of the biggest of the brothers in the family of giants springing from the union, under the magic influence of the electric spark, of atmospheric air and petroleum in the internal-combustion engine, the commercial operation of aircraft, the scope and importance of the problems that must be given immediate and careful attention and study by the engineer are so great that I venture the prediction that within the next 10 years there will be a larger number of engineers engaged exclusively on them than there are today in the total membership of this Society.

It seems that Mr. Manly anticipated the amendment that is proposed by about 6 years, and it appears logical to have such an amendment made when it can be seen that there is a group of approximately 700 active members who can be classified as being represented under the classification of doing operation and maintenance work.

Archibald Black seems to make light of the suggestion and feels that it is absurd to ask a motor-truck operator to represent certain other lines of manufacture. I fear that he has drawn the wrong deductions from the proposed amendment. Nothing is contained in the amendment which to any degree places the motor-truck operator in a class by himself. The nomination for a vice-presidency representing this group, or any other group for that matter, rests entirely in the hands of the Nominating Committee, and if they saw fit to select a man from the aviation industry, or any other line of industry, which is now represented by a vice-president, there are no limitations on their doing so. It can, therefore, be seen that Mr. Black's suggestions have received careful consideration.

Mr. Bachman brings up the point as to whether the vice-presidencies are properly serving the Society at present. This, I assume, is a matter that should receive careful consideration periodically. From my viewpoint, it appears to me that the Society has prospered greatly under the present plan of organization, and in view of this prosperity, it seems to be out of place to overhaul the constitution as a whole.

Having come into contact with a large group of members since presenting this amendment, a feeling has been expressed to me that the Society was going outside of its scope as an engineering organization. This certainly depends entirely upon the viewpoint of the individual. Personally, I am inclined to believe that what is needed in many cases is a broader viewpoint being taken of the whole subject, or the definition of what constitutes a real engineer. Personally, I am ready to accept the definition that has been given, and which is on display at our headquarters in New York City, which reads—

The art of organizing and directing men and controlling forces and materials of nature for the benefit of the human race.

If the members as a whole, in considering the proposed amendment, will keep in mind the above definition and thoughts, I am reasonably certain they will, as a group, gather the thought that the proposed amendment is a logical one and represents a line of industry that is distinctly covered by the above definition and plays a prominent part in the operation of the Society, and that the group therein are worthy of the special consideration which is being given to them in this instance.

What is actually needed is the establishment of a vice-presidency for a group of men that are taking a very active part in the affairs of the Society, and from which the Nominating Committee can pick a representative that will do credit to the Society as a whole. It is safe to predict that with advancing years the vice-presidency being advocated in this instance will assume a very active part in directing the affairs of the Society.

H. M. CRANE:—I find myself, as is often the case, in complete accord with the position of Past-President Bachman. I have been trying to figure out some proposition that would meet with general support and would provide solely enough Vice-Presidents to take care of any possible question of succession; and I admit that the problem is a difficult one.

We have always found, in the affairs of the Society, that it is easier to give something more than to take anything away where an apparent vested interest is involved. I thoroughly believe that the Society would benefit in the long run from having a President, a First Vice-President, a Second Vice-President and possibly a Third Vice-President, and a Council of the present size, with no particular restriction as to the phase of the industry represented in each case. In my opinion, the availability of a candidate for office should be determined on the basis of his general ability and of his proved willingness to work for the Society. As Mr. Bachman justly states, there has been no apparent class consciousness shown in the various branches of engineering recognized by the present list of Vice-Presidents. This is entirely natural in view of the continuous interchange of personnel and overlapping of different lines. For instance, I was at one time Vice-President representing aviation engineering, while at the present time I am probably more interested in motor-car engineering. Past-President Vincent adds motor boating to the other two; and so it goes.

About the only relation in the affairs of the Society that has developed class consciousness is the relation between Sections, and I would be inclined to feel that there is fully as much justification to allot Vice-Presidents to different Sections as to the different phases of the industry.



# Balloon Tires for Motorcoaches

By J. M. LINFORTH<sup>1</sup>

CLEVELAND SECTION PAPER

Illustrated with DRAWING

## ABSTRACT

THAT low-pressure, or balloon, tires for motorcoaches are coming into use faster than is realized by most motorcoach engineers and that the public will demand this new type of tire equipment is the belief of the men in the highway transportation department of the company with which the author is connected. This belief is based upon their experience with the new tires, gained during several years' operation of small motorcoaches on single rear-wheel balloon-tires and, since 1923, with dual balloon tires on larger vehicles. Since 1923 approximately 300 low-pressure motorcoach tires have been put out and their performance watched closely. Reaction of the passengers to the effect of a set of the tires on a 29-passenger Model-Y Yellow Coach operated over a 72-mile route is indicated by the enthusiastic comments on the superior riding-comfort that were made on inquiry cards distributed by the operating company and returned by the passengers to the coach driver.

The low-pressure motorcoach tires are now in regular factory production in seven sizes, all designed for an inflation-pressure of 45 lb. and for load capacities ranging from 2100 to 3000 lb. The 36 x 8.25-in. size is expected to be the most popular, since it is the most suitable for the average 29-passenger motorcoach. It is believed that the proper application of the balloon tires is on new vehicles, as fitting them in place of high-pressure tires on dual wheels requires a new design of wheel and, usually, a new design of hub and brake drum.

Tests have shown greater mileage for the low-pressure than for high-pressure tires, and experience seems to indicate that they will give at least as much mileage as the latter in regular service. From actual results obtained, the author and his co-workers are convinced that they will not puncture any more easily or frequently than high-pressure tires. Two rear tires on a 16-passenger motorcoach went through an entire winter without a puncture and averaged more than 80 per cent of their total useful mileage of more than 35,000 miles before going flat.

Increased average running speed of the vehicle is an important advantage conferred by the tires, as is also the fact that in wet weather they hold the road better and permit quicker stops than high-pressure tires.

In the adoption of balloon tires by the motorcoach industry, serious thought should be given to the question of the best wheel-diameter, as there has been considerable discussion of the heat generated by the brakes, especially on 20-in. wheels. A wheel size between 20 and 24 in. probably would avoid the heating trouble.

LOW-PRESSURE, or balloon, tires are coming into use on motorcoaches and motor trucks at a much faster rate than is realized by most motorcoach engineers, in the belief of the highway transportation department of the Goodyear Tire & Rubber Co. If our experience with balloon tires on passenger cars signifies anything, we can foresee the riding public demanding low-pressure tires on motorcoaches. This belief is confirmed by the fact that each installation of balloon tires

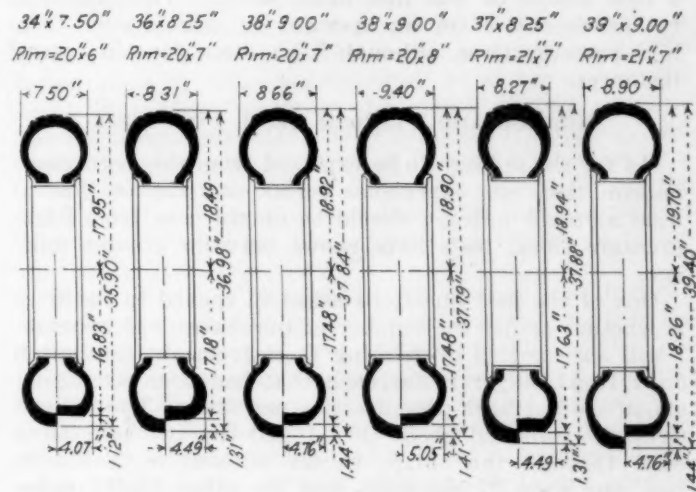


FIG. 1—VARIOUS SIZES OF BALLOON TIRES FOR MOTORCOACHES NOW REGULARLY PRODUCED

In Addition to the Tires Shown the Goodyear Line Has One More Size, 35 x 7.50 In. This Tire Has a Normal Over-All Diameter of 36.90 In. The Normal Sectional Diameter Is 7.50 In. and the Horizontal Dimension Becomes 8.14 In. when Deflected. The Inflation-Pressures and Load Capacities for the Complete Line Are Given in Table 1

on a motorcoach has produced enthusiasm on the part of the operator because of the greatly improved cushioning provided, the greater minimum speed and the increased transportation-selling appeal of the vehicle. The passengers have commented favorably upon the greater riding-comfort and the decrease in noise.

Although we have been running small motorcoaches on balloon tires for several years, our first experience with dual balloon tires was in 1923. Since then we have put out approximately 300 balloon tires for motorcoaches and watched their performance closely. Some minor changes in the tires were made during this experimental period but even the first tires gave excellent service. Seven sizes, all but one of which are shown in section in Fig. 1, are now in regular factory production, in the dimensions and load capacities given in Table 1. Of these sizes, the 36 x 8.25-in. size probably will be most popular, as this size has been found most suitable for the average 29-passenger motorcoach. The 34 x 7.50-in. size will be used on vehicles of smaller capacity. The use of too small a size must be avoided if real balloon-tire effect is desired. In our experiments we used 34 x 7.50-in. tires on a 29-passenger motorcoach and found some improvement in riding-qualities over the high-pressure tires, but the improvement did not compare with that

TABLE 1—MOTORCOACH BALLOON-TIRE SIZES IN REGULAR PRODUCTION

Size, In.	Load Capacity, Lb.	Inflation-Pressure, Lb.
34 x 7.50	2,100	45
35 x 7.50	2,100	45
36 x 8.25	2,500	45
37 x 8.25	2,500	45
38 x 9.00	3,000	45
39 x 9.00	3,000	45

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afforded by the 36 x 8.25-in. tires that were applied later. With the 36 x 8.25-in. tires the short sharp vibrations of the vehicle were noticeably absent and the large upward movements caused by passing over large obstructions were extended over a longer period.

We believe that the proper application of balloon tires is on new motorcoaches as original equipment. In practically all dual rear-wheel use, the equipment with balloon tires requires a new design of wheel, and usually a new design of hub and brake drum. This makes it rather expensive for an operator to change over from high-pressure tires, although it has been done in several instances.

#### MILEAGE AND FREEDOM FROM PUNCTURES

As for the mileage to be expected from the motorcoach balloon tire, our experience seems to indicate that at least as much mileage should be obtained as from high-pressure tires; tests have shown actually greater mileage.

One of the first questions asked in regard to the tires is whether or not the number of punctures will increase. I will answer this by relating facts from an installation on a 16-passenger motorcoach that had been averaging about one flat high-pressure tire per week. The balloon tires were applied about Oct. 1 and the two rear tires went through the entire winter without a "flat"; in fact, one went 27,965 miles and the other 29,485 miles without a puncture. Stated in another way, they ran more than 80 per cent of their full mileage without a puncture, as they averaged a total of more than 35,000 miles. Each of the two front tires went flat once during the winter. This is only one of many installations that showed similar results. I do not wish to convey the idea that motorcoach balloon tires will not puncture, but we are convinced from actual results that they should not puncture more easily or frequently than high-pressure tires.

One of the important advantages derived by the use of balloon tires is the decrease in running time of the vehicle due to an increase of the minimum speed without any increase of maximum speed. It is easy to account for this when it is observed how, with high-pressure tires, speed is reduced when going over rough stretches of road, whereas, with balloon tires, an even speed can be maintained.

We have found that the motorcoach balloon tires hold the road on wet as well as dry surfaces much better than high-pressure tires. Many operators have remarked that they are able to make stops with balloon tires that would be impossible with high-pressure tires. Thus the balloon tires add to the safety of motorcoach operation.

#### INDICATION OF PUBLIC ACCEPTANCE

Probably the comments of the patrons of one of the motorcoaches fitted with the tires will give a better idea of the acceptance of balloon tires than could be presented in any other way. This coach operates over a route of 72 miles of concrete and macadam road which is in need of resurfacing in some sections. Corrugations make sustained speed with comfort out of the question on high-pressure tires. The vehicle is a Model-Y Yellow Coach of 29-passenger capacity. As each passenger entered, he was handed a printed card stating that the coach was fitted with balloon tires and asking him to write on the back of the card any comment he wished to make and return the card to the driver. Beginning with the first round-trip of the coach, comments began to pour into the office of the operating company. Thirty-three cards in the first batch commented most favorably and enthusiastically upon the superior riding-comfort. Some stated that the writers were able to read newspapers and to correct copy proof during the ride and others commented upon the driver's skill and observance of traffic rules. These comments indicate the public interest in motorcoach balloon tires. Such tires contribute definite improvement to highway transportation, and transportation always has been prone to adopt eagerly any development that will save time and add to the comfort of the traveler. Balloon tires accomplish both of these advances.

#### PROPER DIAMETER SHOULD BE CONSIDERED

In adopting balloon tires for motorcoaches, considerable thought should be given to the question of the proper diameter for them. We all have heard considerable discussion in the last summer of the heat generated by brakes, especially on the 20-in. wheels for high-pressure tires on motorcoaches. The fact that wheels of 24-in. diameter are evidently free from this damaging heat seems to indicate that a diameter between 20 and 24 in. probably would avoid this trouble.

At a recent meeting of the Rubber Association of America, held in New York City, the following sizes for motorcoach and truck balloon tires, to be added to the ultimate standard tire sizes as presented to the car builders on Sept. 3, 1924, were suggested: 35 x 7.50/21, 37 x 8.25/21 and 39 x 9.00/21 in.

The tire committee decided at this meeting to recommend the addition of these sizes with the understanding that they might, in a few instances, have to be made for 20-in. wheels, and a strong recommendation was adopted that every effort be made to limit production of these new balloon cross-sections to 20 and 21-in. inside diameter.

## MARINE CONSUMPTION OF FUEL OIL

ACCORDING to returns received by the American Petroleum Institute from the principal companies engaged in the marine fuel-oil business 79,173,000 bbl. of fuel oil was delivered for ships' bunkers at ports of the United States and its insular possessions in 1925, compared with 80,880,000 bbl. in 1924, a decrease of 1,707,000 bbl. or 2.1 per cent. This is exclusive of fuel oil delivered to the United States Navy, which in 1925 consumed approximately 6,300,000 bbl. compared with 6,300,000 bbl. in 1924. This figure includes Diesel engine oil and covers consumption by naval vessels, but does

not include consumption at navy yards and shore stations. Of the total deliveries of 79,173,000 bbl. to merchant vessels in 1925, 50,925,000 bbl. was domestic fuel-oil and 28,248,000 bbl., foreign fuel-oil. Deliveries at Atlantic coast ports totaled 29,489,000 bbl. or 37.2 per cent of the total delivery. Deliveries of domestic oil at Atlantic coast ports totaled 14,377,000 bbl. or 28.2 per cent of the total domestic-oil deliveries. Deliveries at Gulf coast ports totaled 17,174,000 bbl. or 21.7 per cent of total deliveries.—From American Petroleum Institute Bulletin No. 23.

# The Training of Future Executives

By JOHN YOUNGER<sup>1</sup>

CLEVELAND SECTION PAPER

## ABSTRACT

AFTER citing the highly competitive conditions in the automotive industry, the development of new metals and of improved time and labor-saving processes and methods, comment is made that direction in the use of these modern materials and production methods calls for intelligence of a high order. Such intelligence must be trained, however, and the basis of the training is the accumulated experience of years. While the final practical training must be given in the manufacturing establishment, the mind of the young man who expects to become an executive should be prepared by preliminary training to absorb knowledge rapidly so that promotion may be reasonably fast.

Universities and colleges provide varied courses for this preliminary training, in which the students are taught how to learn. Some of the larger electrical companies make a practice of influencing the courses, of pointing out the opportunities for advancement afforded in their organizations and of drawing the better qualified graduates into their employment. They also maintain training courses for a year in which the graduates become adjusted to the industrial conditions under which their future work will be carried on and acquainted with the policies and methods of the company.

While the automotive industry is now the largest in the Country and offers great possibilities to young men, it is doing practically nothing along these lines. Suggestion is made that the Society and the National Automobile Chamber of Commerce should appoint educational committees and, by maintaining contact with the educational institutions, assure that the teaching shall represent modern practices. The Society now has a means of contact through its Student Group plan. Students can have outside contacts, through THE JOURNAL and through speakers provided by the Society at Student Group meetings to acquaint them with the affairs and problems of the industry. The National Automobile Chamber of Commerce might advertise cooperatively the great opportunities offered to young men by the industry, or individual companies could present the advantages afforded by their own organizations. They could also institute training systems for those who enter their service. Although the industry is still young, it is not too early to begin to think of the future.

WHAT are the weapons used in the highly competitive struggle that is going on in our automotive industry? We see today a concentration of manufacturing organizations in which the weaker are pushed aside to perish. Materials that were laboratory products a few years ago are today supplied on a commercial scale and the art of developing them goes on apace. Alloy-steels, such as high-chromium alloys, that were unknown until recently are being discovered and their immediate utilization in the industry is being sought. Magnesium, only recently a comparatively rare metal, is now being developed as a piston material. Thus the search goes on.

In processing we have similar developments. Fabrication, formerly an erratic function performed between long intervals of handling the material, now proceeds with a straightforward certainty that brings far-reach-

ing results. Not so many years ago, machines were grouped according to class in the order of their similarity. All lathes, for example, were segregated in the lathe department. Today, machine-tools are arranged in the order of the work that is done. A lathe may stand next to a milling-machine, a heat-treatment unit beside the lathe and a grinding-machine may be at the end of the line. Work flows smoothly and quickly through its successive operations with the minimum of handling, and that limited amount of handling is more often done by a conveyor system. Alvan Macauley, president of the Packard Motor Car Co., stated recently that a saving of less than 1/4 cent per piece justifies a change in manufacturing operations.

New arts have developed. Tools, jigs and fixtures, formerly regarded as minor subjects, have come into the limelight as a major part of mechanical design. The activities of the planning engineer, production engineer and industrial engineer are all new to this generation.

Behind these factors of materials and processing lies the most important factor of all, that of the human element, the intelligence that makes these things possible. The following questions then arise:

- (1) Is there a need for training future executives?
- (2) What kind of training is desirable?
- (3) What are the facilities for such training?
- (4) What becomes of those who utilize these facilities?
- (5) Are companies taking advantage of such facilities?
- (6) Is the automotive industry using them?
- (7) Can the industry benefit by using them?

Directing intelligence starts, not from scratch, but from the accumulated experience of previous years. It has, or should have, a fund of information and records behind it, that is, it should be a trained intelligence. Unless it is trained it starts, not only from scratch, but with a heavy handicap. An untrained mind cannot grasp the significance and application of the recent advances in metallurgy and metallography that have made modern materials possible. An untrained mind cannot grasp the fundamental records behind the progress that is now made in processing. To enable the men who are to carry on the operations to have this understanding, they must be given a very thorough training. The question is, Where can this training best be given?

## PRELIMINARY TRAINING IS NEEDED

It will be agreed, I think, that such training must not be a hit-or-miss affair. Such methods are, at best, only 50 per cent right, and 50 per cent right is not enough in this severe competition. If materials and processes are to be the very latest and best, then we must see that in this industry the personnel that works with them shall be trained to the fine-point also. The basis of most of this training must be accumulated experience. The most practical part must be given by the manufacturing establishments themselves. At the same time, one important element that the industry should not allow itself to overlook is that there can be an initial fundamental training that will, in a sense, train men so that they can be trained in a particular line more easily and more rapidly. It is not enough merely to train a man or give him experience. Such a process may be prolonged over too long a period; the man may die before his acquired knowledge

<sup>1</sup>M.S.A.E.—Publisher and editor, *Automotive Abstracts*; professor of industrial engineering, Ohio State University, Columbus, Ohio.

can be utilized. The element of time enters into the training, and the faster a man can be trained, the earlier the employer can realize upon his potentialities.

Man's capacity to absorb has often been likened to that of a sponge; but man differs from a sponge in that he can be taught to absorb at increased speed. This preliminary training can best be given in our colleges and universities. In the grammar and high schools we teach the young the nature and elementary use of the tools of reading, writing, arithmetic, and speech. In the universities we teach them the fundamental uses to which these tools can be put, either for business or for a cultural leisure. They are taught how to learn, how to absorb knowledge. After completing a university course, they are better equipped with capacity to absorb further training at a high rate of speed.

#### SUPPLEMENTAL MODIFIED APPRENTICESHIP COURSE

Universities now offer a wide variety of courses suitable for training future leaders. For example, at Ohio State University courses in business law, patent law and the like for corporation executives are given. The college of commerce and journalism offers courses in business administration, economics, accounting, traffic matters, and the relations of labor to capital. The college of engineering offers training to the young man who wants to become a metallurgist, a metallographist, a design engineer, a production engineer, an industrial engineer, or, last but not least, an automotive engineer.

University authorities do not feel that students who graduate from these courses "know it all." On the contrary, and very decidedly, they feel that such courses provide merely fundamental training to prepare the student to become an executive when he has had the necessary supplementary training outside the university. A college training, in the words of my old teacher, fits a man to learn a thing faster than the boss can find out that he knows nothing about it. In many cases it is advisable to supplement the university course with a modified apprenticeship course of, say, 1 year at most. During this year the graduate will become oriented or adjusted to the industrial conditions in which he will work during his career. Transition from college life to industrial life is a tremendous change for most students, and it is important that they be given time to become accustomed to the changed conditions.

#### RESULTS OF COLLEGE TRAINING

Let us analyze the final results of this student training as revealed in the field of electrical transportation, which is the most nearly similar to the automotive field. From this industry 1066 executive officers were selected at random. Of these, 580, or 54.4 per cent, have been graduated from college, and of this 54.4 per cent 357, or 61.3 per cent, were graduated from schools of engineering and 223, or 38.7 per cent, from academic and law courses. In this major group are 151 presidents, of whom 92, or 60.9 per cent, are college-trained, 45.0 per cent are from academic colleges and 37.0 per cent from engineering colleges. Many of these presidents have been in the industry more than 20 years, which shows that even 20 years ago the college man proved of considerable worth in this industry and that all of the glory did not fall to the lot of the "steady plugger" who had never been to college.

The percentage of vice-presidents with college training is about the same, 67 out of a total of 122, or 54.9 per cent. However, the engineering graduates outnumber the academic graduates by 13, numbering 40 in all, or

59.7 per cent. Of 215 general and local managers, 126, or 58.6 per cent, have college degrees; nearly 66.7 per cent of this group are engineers. The highest percentage of men with higher education is in the engineering group; of 31 chief engineers, 80 per cent are college graduates. Incidentally, many electric-transportation companies make a practice of grouping college men and training them directly for executive positions.

The three largest electric companies, General Electric, Westinghouse Electric & Mfg. and American Telephone & Telegraph, train only college graduates for executive positions. They have developed the process into a fine art. First, they establish intimate contact with the particular members of the faculty whom they desire to reach. By entirely proper and justifiable means, they exert an influence on the courses taught, so that the student's minds are prepared in a way that will make the men most useful to the companies. Obviously, the colleges that turn out graduates who most nearly meet the requirements of these companies will find a readier demand for their students. The law of supply and demand functions in the field of engineering personnel just as in business. The college that has the greater demand for its graduates is the more desirable place for the student to enter. Consciously or unconsciously, therefore, the faculties model their curricula to suit the demand.

The next step of the electric companies is to send representatives to speak at student meetings and paint in more or less glowing colors the desirability of entering the service of their respective companies. This has a strong effect upon the students who are considering the momentous jump from college life to industrial life and whose minds are very receptive of the industrial ideas put before them. The final step is to have these representatives come with contract forms to interview prospective graduates individually. In the course of these interviews the men are graded according to the impressions they make upon the companies' representatives. The result is that only the better-qualified students are selected.

Try to place yourself in the student's frame of mind and consider how this last step would affect you. You expect to enter industry within a few months; you probably have not applied for a job before; you are faced with what appears to you to be a very uncertain future; you have a leaning toward work of a certain kind but have no idea how to go about getting into it. Out of the darkness shines a ray of light, in this case electric light. Naturally, it attracts you and you gravitate toward it. You cannot help being impressed by the talk of the vocational representatives from the big companies and probably you will decide to go to work for one of them. So you follow the line of least resistance and enroll in the electrical industry to become eventually one of the executives.

#### AUTOMOTIVE INDUSTRY NEGLECTING AN OPPORTUNITY

What is being done in this respect by the automotive industry? Very little, and that only in an individual way. Some companies, as the Olds Motor Co., Timken-Detroit Axle Co., Timken Roller Bearing Co., Remy Electric Co., White Motor Co., and several of the rubber companies, definitely seek out graduates with a view to enrolling them as employees in training for executive positions. But these firms are in a decided minority. True, it is said that colleges do not train automotive men as such, except as a side-line; but whose fault is that? The cycle of training for industry does not always start with the university. It should be started by a demand from the

manufacturers for a human product that is most suitable for their needs.

I often marvel at the automotive industry. It is the largest industry in the Country and its products include all means of individual transportation. The airplane, the automobile, the motor truck, the motorcoach, and the tractor are all products of its skill. It uses practically every material, metallic and non-metallic. It makes use of all the forces known to man and employs the sciences of chemistry, physics, metallurgy, and thermodynamics to further the successful development of its products. Yet, in the field of training personnel, it is weak. We have not yet solved all of our problems, by any manner of means; and these problems are becoming more complex and more scientific as time goes on. Problems of the future will require a high degree of intelligence for their solution, and this intelligence must be trained. Manufacturers in the automotive field should take action to assure that the early training of young men who will later enter the industry will give them the necessary fundamentals for their promotion with reasonable rapidity.

#### UNIVERSITY CAN TRAIN IN FUNDAMENTALS ONLY

It is recognized fully in this discussion that the university can be only a training-ground in the fundamentals. Further and more specific training can and must be given in the industry itself. I realize that the old apprenticeship systems have been abolished forever. Modern tools and the modern system of single-operation production make it possible to train an individual worker in 6 days so that he will be profitable to a company. A much longer time is required, however, to train our planners and leaders. One of the most important phases of such training might well be a study of the policy and practices of the company. Men should not be left to pick this knowledge up haphazardly; on the contrary, it should be imparted to the young entrant in a constructive way so that it can be grasped readily and accurately.

The Westinghouse Electric & Mfg. Co. maintains a school which the young graduate enters for 1 year. Here he learns the policy of the company, its system of manufacturing, its products, and the markets to which they go. His time in the school is a year of preparation for the industrial work that is before him. During this year his work is scrutinized; experienced men are estimating his capabilities to determine whether or not he is of the timber to become in time a Westinghouse executive.

Similar courses exist at the American Telephone & Telegraph Co., the Western Electric Co. and the General Electric Co. There may be such also in the automotive industry but, if so, they are not so well known and the better students do not gravitate toward them. The choice goes elsewhere.

Another point is that the big electrical companies named advertise their advantages to the graduating students in student newspapers and magazines. Other companies, such as Babcock & Wilcox, send out, for distribution to students, elaborate booklets telling what their industry offers in the way of employment and promotion.

#### SPLENDID OPPORTUNITIES IN THE INDUSTRY

The wonderful automotive industry, which calls for the best of man-power, does practically none of these things. After an experience of 25 years in the industry, I am convinced that it offers splendid opportunities to young men. In the replacement market alone we are facing a production of more than 3,000,000 cars a year, and the public is demanding better and better cars. The motorcoach business is still in its infancy; new problems are arising every day in design, operation and maintenance. The passenger-car and motorcoach branches offer excellent fields to intelligent young men.

Meanwhile, we are doing nothing to attract these men. I suggest that this is a problem partly for the Society and partly for the National Automobile Chamber of Commerce to solve. The Society could do as the American Society of Mechanical Engineers has done and establish an educational committee to study the various automotive courses offered in the colleges and universities. By maintaining contact with these institutions of learning it could go far in assuring that the teachings shall represent modern practices. A means of contact has been created already by establishing a Student Group at Ohio State University. The Massachusetts Institute of Technology, Purdue University and the Universities of Michigan and California are expected to take similar action promptly. This procedure will place THE JOURNAL of the Society in the hands of students and will develop in them a knowledge of automotive affairs and problems outside of their own scholastic courses. A further outside contact will be established if speakers before meetings of the student groups are obtained through the offices of the Society.

The National Automobile Chamber of Commerce, for its part, might consider the advisability of cooperative advertising of the opportunities afforded by the industry as a whole as a worthwhile business career; or, representative companies could advertise the advantages available in their own organizations. Speakers could bring these facts to the attention of students, other representatives could be sent by the companies to make employment contracts with interested students. These companies could also institute definite training-systems for the entrants to shorten the learning period and hasten the time when the student can become a profitable worker.

The industry is only as strong as its man-power, and, young though the industry is, it is not too early to begin to think of the future.

#### EXPORTS OF AUTOMOBILES

**E**XPORTS of automobiles and trucks from the United States in 1925 totaled 302,924 units, which compares with 178,732 units in 1924 and 171,644 in 1920. In 1913 only 26,889 cars and trucks were exported. The total value of cars and trucks exported in 1925 was \$222,599,132, a gain of 66.4 per cent over 1924 and of 4.9 per cent over 1920, the previous record year. Last year thus set new high records for the number of units exported and for their value.

Australia was the largest taker of passenger cars in 1925, receiving 48,351 units. Other large buyers were Argentina, with 31,489 cars; the United Kingdom, 17,569; Brazil, 13,974; Canada, 13,928; Mexico, 12,560; and British South Africa, 11,990. Australia was also the largest purchaser of trucks and motorcoaches, taking 7549 units while Italy took 4419; Brazil, 4695, and the United Kingdom, 4320.—*Economic World*.

## SECONDARY METALS IN 1924

THE collection of waste material is an established branch of industry. It involves the collection, sorting and shipment of waste having an estimated value of more than \$1,000,000,000 yearly; it has advanced in honesty, efficiency and usefulness; and it is growing rapidly. Better-equipped plants handle the material, and technical methods of handling and using waste are rapidly superseding ignorance and guesswork.

Few people realize the ramifications of the trade in waste materials; few realize its importance in keeping down costs of many products, such as containers; few realize how the prices of metals and of many other commodities would soar if waste products did not supplement the stocks of primary materials. The advertisements in trade papers devoted to waste materials indicate that nearly every variety of waste has a market, and yet adequate statistics on quantity and value are available for only a few classes of it. Among the wastes offered for sale are iron and steel, rags, jute and cotton bags, paper sacks, hair, feathers, picture films, old hats, bones, broken glass, paper of all kinds, barrels, rope, roofing, shoes, scrap leather, celluloid, canvas, tubes, casings, hair-cloth, and carpets. The value of some of the varieties of waste aggregates millions of dollars and would be much greater if the cost of collecting, sorting and shipping were not so high. Some European metal dealers have established American agencies for the purchase of scrap and drosses. In 1924 exports of waste metals from the United States increased, imports from Europe declined and exports to Europe exceeded the imports. In some classes of old metals and alloys the competition between Eastern refineries and smelters and the foreign buyers was very keen and prices were high. Every year an increased number of foundries and metal-working establishments carefully segregate all waste made at their plants. The expense of doing this is quickly returned in the better prices obtained for waste metals sold. Various trade papers, such as the *Waste Trade Journal*, *Daily Metal Trade*, *Brass World*, *American Metal Market*, *Foundry*, *The Iron Age*, *Iron Trade Review*, *Metal Industry*, and *Daily Metal Reporter*, contain valuable information relating to prices and marketing of scrap metal and drosses and technical information relating to the proper use of old metals. The classification of old metals drawn up by the metal division of the National Association of Waste Material Dealers and changed from time to time as is found desirable has become the standard with both dealers and manufac-

turers who are located throughout the entire length and breadth of the United States.

The recoveries of secondary lead, tin, antimony, aluminum, and nickel increased in 1924, both in quantity and in value. The average price of all the above metals except nickel was greater in 1924 than in 1923. The average price of copper, however, was 1.6 cents less in 1924 than in 1923, and the large decrease in remelted brass scrap and a considerable decrease in the quantity of zinc recovered by redistillation and remelting more than offset the increased quantity and value of the other metals. The decrease in total value from the year 1923 was \$4,840,000, or 2 per cent, and the decrease in quantity of metals and alloys recovered was also about 2 per cent. The decreases, however, were not in scrap metals available and collected but in such material smelted and refined, for much larger quantities of waste metals and drosses of certain classes were exported and much smaller quantities imported in 1924 than in 1923. The recovery of secondary aluminum as pig aluminum or in alloys in 1924 amounted to 27,000 net tons, valued at \$14,596,200, compared with 21,300 tons, valued at \$10,824,600, in 1923.

Large adequately equipped companies, and many of them having widely distributed plants or selling agencies, handle the bulk of the nonferrous scrap and drosses. Buying large quantities of metals and drosses and employing metallurgists and chemists, they can use scrap to the best advantage and sell metals and alloys on close specifications or by brands. The tendency in the secondary-metal industry will be more and more to consolidation, at it has been in other important industries. The change will bring a steadier supply of guaranteed metals and alloys and induce more foundries and other plants to buy alloys and composition metal instead of virgin pig metals and metal scrap.

A considerable part of the ferrous metal scrap contained nickel, tungsten, manganese, chromium, vanadium, molybdenum, or other alloy metals, which made it much more valuable than the ordinary commercial iron and steel scrap, though the market is limited and some knowledge regarding consumers is necessary in finding prospective purchasers. The railways are, on the whole, the largest producers of most kinds of metal scrap, as well as the largest users of new and remelted metal. It is estimated that the railways usually supply more than 30 per cent of the scrap iron and steel, and industrial plants nearly as much.—From *Mineral Resources of the United States*, 1924 edition, part 1.

## PUBLICITY

PUBLICITY in its broadest sense, I think, means anything and everything that causes the public to form an opinion of our company. It may be what people observe, or what they hear, or what they read. What people observe of our service, our plant or our employees is publicity; what people hear from our employees also is publicity, as well as what they read in our advertisements, our company magazine or other printed matter.

Publicity enters into every activity of our company. Every employee in every department is our company's publicity representative, because all have more or less contact with the public, and through those contacts the company receives publicity. The publicity policy of our company is this: To conduct our business so as to merit public approval, to let the public know at all times what we are doing and why and to use every practical means to explain our problems, policies, practices, aims, and the like.

All three partners in the telephone business—employees, investors and the public—are benefited by this thing we call

publicity—this mighty force whose purpose is to win and hold public understanding, confidence and cooperation. And public confidence and cooperation, I think, come only by doing the following:

- (1) Providing the public with adequate and dependable service
- (2) Giving the public the right impression of us from what they observe of our employees, our methods and our plant
- (3) Giving the public complete information about our business through what they hear from our employees, and our former employees and what they read about us in newspaper advertisements and other printed matter

All this is a publicity job—the publicity job in which every man and woman in our organization has a part and by means of which, when the job is done well, it benefits telephone employees, investors and the public.—F. C. Bulta in *Printers' Ink*.

# Lubrication of Plain Bearings

By D. P. BARNARD, 4TH<sup>1</sup>

METROPOLITAN SECTION PAPER

Illustrated with PHOTOGRAPHS

## ABSTRACT

**S**URFACES that slide upon one another can be lubricated by one of two mechanisms, (a) heavily loaded surfaces working at slow speed depend upon the oiliness of the lubricant and (b) high-speed bearings depend upon its viscosity. In the latter, conditions must be adjusted so that an adequate supply of lubricant will be provided and an opportunity given for it to be trapped between the surfaces and actually to wedge them apart. The bearing must therefore have a certain clearance over the journal. Oil-grooves must supply means for the oil to enter the bearing and the assurance that it cannot escape without doing its work. In general, they should not be placed on the loaded side of the bearing. The tendency is to draw the oil from the point of minimum pressure through that at which the pressure is the maximum, and for the oil to spread out and travel in a spiral along the bearing toward the ends.

With a view to making an investigation of the behavior of the oil after it has reached the bearing, a visual study was made by means of a glass bearing and the results were reproduced by a film, the action of the lubricant being made visible by introducing into the oil a small quantity of dyed glycerine solution of about the same viscosity as the oil. A description is given of the results obtained.

**I**T is a well-recognized fact, at least in literature, that two sliding surfaces can be lubricated by one or the other of two mechanisms. One, occurring primarily in bearings that are heavily loaded and working at slow speed, is due to oiliness. The other is due to the viscosity of the lubricant and is called fluid-film lubrication. This consists of a film of fluid that is maintained between the two rubbing surfaces in spite of the load that may be carried and is the type that must be maintained in high-speed bearings. By high-speed bearings are meant bearings such as those of automobile engines and, of course, all bearings operating at higher speeds.

The fluid film is formed by the action of the lubricant in adhering to the journal, and, in the case of a revolving journal, in dragging the lubricant along with it between the rubbing surfaces. Conditions must therefore be adjusted so that an adequate supply of lubricant will be provided and an opportunity be given for it to be trapped between the rubbing surfaces and actually to wedge them apart. Consequently, the bearing must have a certain clearance over the journal. In addition to the proper clearance, a certain flow of oil through the bearing must be present from some point at which the journal can pick it up, through the portion that is carrying the load and out at some other point.

A bearing fitted with the proper clearance normally has all the exit space for the used oil that is required and at times the end leakage from bearings is entirely too high. Another item that is important in designing bearings is the providing of a proper means for the entrance of the oil into the bearing and the assurance that the oil cannot escape without doing its work. This

requires that oil-grooves be in the proper location for the oil-supply, and making sure that no oil-grooves are located where a surface for carrying the load should be located. In general, no oil-grooves should be placed in the loaded side of the bearing.

## MECHANISM OF THE FLOW OF OIL

A study of the mechanism of flow through a bearing has shown that the oil is drawn from a portion of the bearing carrying no load and is carried through the load-supporting portion of the bearing. As it approaches the point of load, the pressure in the film naturally must increase to support the load so that somewhere along the line of travel, half-way between the two ends of the bearing, is a point at which the pressure is the maximum. On the opposite side of the bearing, where no load is, is a point at which the pressure is the

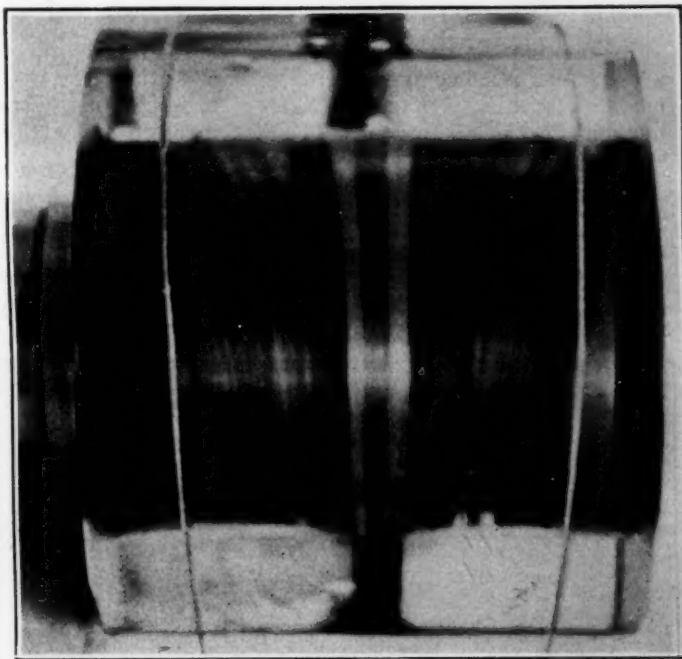


FIG. 1—OIL-FLOW AS SEEN THROUGH A GLASS BEARING. The Operating Conditions Here Were Such That a Relatively Thick Supporting Film Was Formed and the Oil Followed Closely the Direction of Journal Rotation

minimum. Because the pressure is high on the loaded side, the oil tends to flow toward the ends of the bearing; on the unloaded side where the pressure is low, it tends to flow toward the inner part of the bearing. The general tendency, therefore, is for it to spread out and travel in a spiral along the bearing toward the ends. That being the case, oil-grooves in the bearing should be placed in the unloaded side where the oil can naturally and easily obtain entrance.

Placing the oil-grooves on the loaded side of the bearing does not put the oil where it is needed, as is commonly supposed, but merely tends to decrease the effective area of the surface that can produce a supporting film,

<sup>1</sup> M.S.A.E.—Research engineer, Standard Oil Co. of Indiana, Whit-  
ing, Ind.

and allows the oil either to return or to leak out at the ends without accomplishing its purposes. In oil-grooving for any particular bearing, an attempt should be made to assist the natural flow of oil as much as possible, because the natural flow forms the protecting film and, in the case of certain bearings operating under an extremely high speed, helps to carry off part of the frictional heat that is developed. No fixed method of determining just what percentage of the frictional heat is carried away by the oil has been established; no fixed rule can predict it. It is not known exactly how much the oil assists in carrying away the frictional heat from automobile engine bearings, but it certainly can assist to some extent, whether it is necessary or not, and it would seem that as much advantage as possible should be taken of this ability.

Probably, oil-grooves in the pressure side of the bearing serve simply to shorten the effective length of the bearing; if they are placed toward the edge, they reduce the area that can be used to carry the load. The bearing may still work with fluid-film lubrication, but the film will be thinner than it otherwise would have been. The carrying-capacity of the fluid is much greater than is sometimes realized so that bearings in service still endure although the grooving may be wrong. The bearing may not be the best that could be built for the purpose but it may be good enough.

#### VISUAL INVESTIGATION OF OIL-FLOW

In making an investigation of the behavior of oil after it has reached the bearing, a visual study has been made by means of a glass bearing, to show just what happens to the oil and how it flows through a bearing.

<sup>2</sup> M.S.A.E.—Consulting engineer, New York City.

<sup>3</sup> M.S.A.E.—Assistant chief of the engineering division, automotive department, Vacuum Oil Co., New York City.

<sup>4</sup> Jun. S.A.E.—Durant inspector in Hayes & Hunt, Durant Motors, Inc., of New Jersey, Elizabeth, N. J.

<sup>5</sup> M.S.A.E.—Engineer, manufacturers' service division, Vacuum Oil Co., New York City.

<sup>6</sup> M.S.A.E.—Service engineer, T. N. T. Engineering Co., Newark, N. J.

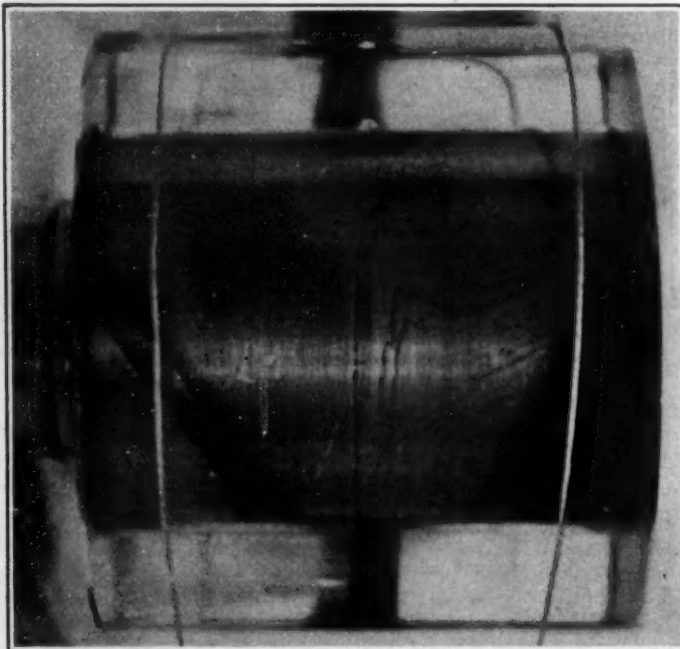


FIG. 2—ANOTHER EXAMPLE OF OIL-FLOW AS SEEN THROUGH A GLASS BEARING

In This Case, the Conditions Were Altered To Allow the Film To Thin-Out to a Marked Degree. The Oil Was Forced More Rapidly Toward the Ends of the Bearing, As Is Shown by the Trend of the Streaks of Dye Solution

For the sake of simplicity, this initial study was made without the use of oil-grooves at all, so that the study shows only the natural course of the oil in flowing through the bearing.

To make the lubricant visible in the thin films in which it exists, a small quantity of dyed glycerine solution of about the same viscosity as the oil was introduced into the oil. This visual study has been recorded on a motion-picture film. The streaks define the path of the oil and are produced by the dye solution put in to show how the oil is flowing. The space between the streaks, which is transparent, is the oil. Except in one or two cases, the film contains no air-pockets. This is purely a fundamental study and as no attempt has been made to reproduce accurately the operating conditions of any particular bearing, the conditions of loading are at variance with current design-practice for bearings. It was absolutely necessary to make this departure. The apparatus was simply small laboratory apparatus, and it was impossible to get enough light through the glass walls on the small surface to make a super-speed photograph. It was necessary, therefore, to slow down the oil-flow to make it visible. The general action is the same at higher speeds.

Figs. 1 and 2 have been reproduced from this motion-picture study. In Fig. 1 the operating conditions were such that a relatively thick supporting film was formed and the oil followed closely the direction of journal rotation. In Fig. 2, however, the conditions were altered to allow the film to thin-out to a marked degree. In this case, the oil was forced more rapidly toward the ends of the bearing, as is shown by the trend of the streaks of dye solution.

This visual study has also shown in a striking manner the effect of moving the oil-hole to the loaded side of the bearing in actually allowing the bearing to suck in air at the ends and to displace the oil backward along the feed-tube. With such an arrangement it would be necessary to provide a very high feed-pressure to ensure the proper flow of oil.

#### THE DISCUSSION

J. A. ANGLADA<sup>2</sup>:—Would the effect be the same if the oil were fed through the journal?

D. P. BARNARD, 4th:—The effect would undoubtedly be the same but it could not be photographed.

G. A. ROUND<sup>3</sup>:—Why is it that, in spite of the fact that the oil is applied on the wrong side of many crankshaft bearings, the units still run and have run for thousands of miles without giving any particular bearing-trouble?

MR. BARNARD:—That is just an illustration of the enormous carrying-capacity of a thin film of oil. In a condition such as you mention the load is actually carried on two short films instead of one. Splitting up the films in this manner must necessarily be accompanied by a decrease in the thickness of the film.

R. BAGGALEY, JR.<sup>4</sup>:—In a pressure-lubricated engine with a drilled crankshaft, where should the oil-holes on the crankthrows be placed, in order that the holes shall be at the point of minimum pressure?

J. W. GRAHAM<sup>5</sup>:—Is it not true that, because of the rupture of the oil-film at the time the bearing comes to rest, no active oil-film is present and reliance must be placed solely on the absorbing property of the metal?

MR. BARNARD:—Yes; that is true.

F. B. HANFORD<sup>6</sup>:—I have seen an oiling system in which the oil-holes in the crankshaft main bearings were drilled tangent to the circumference of the large longi-

tudinal hole that passed through the center of each journal. The outer ends of the oil-holes were relieved in the direction of rotation, which caused an acceleration of the oil passing to the connecting-rods. The increased volume or pressure with this method was about 35 per cent more than that with the radial type of oil-hole.

**R. E. WILSON:**—Oil consumption can be increased in many ways without improving lubricating conditions in the slightest degree; in fact, greater consumption may hurt them, by causing thinner films. The important thing is to get oil into the bearing and to be sure that it does its full duty while it is there. Attention must be fixed upon how much oil is fed through or into the bearing.

**Mr. Howard** said that, theoretically, surfaces could never be made to meet. Of course, that applies even theoretically only to perfectly smooth surfaces. Actually, when the film is thin, giving an irregularity of surface, you must expect to get contact. A great majority of bearings run so that they do not touch a large part of the time. The bearings get hot so quickly that they cannot be run under those conditions. Practically all bearings, however, have metallic contact and abrasion when they start up; and bearings differ mainly with respect to the time required to get out of the region of partial lubrication and into the region of fluid-film lubrication, and in the amount of damage done before metallic contact ceases. Bearings in automobile engines suffer from repeated starting and stopping, but they are peculiarly fortunate as regards lubrication in two respects: First, the loads do not get high until the speed gets high; if the loads at starting were like those at running speeds, the bearings would not last long. Secondly, the loads change in direction; if they were always applied in the same direction, the fluid film would frequently be ruptured.

**C. M. MANLY:**—The fact that, in aviation engines, lubricating oil is usually supplied at considerable pressure, and frequently with special provision for cooling it, may have led to some misunderstanding. Oil is generally supplied to the bearings of aviation engines at from 50 to 100 lb. per sq. in. pressure, not so much with the idea that such a pressure will ensure the building-up of an oil-film in any particular bearing better than a lower pressure will, but that, since so many bearings are fed through fine leads of varying length, it is neces-

sary to carry a considerable pressure to ensure good distribution and thus prevent the starving of any of the bearings. Such pressures are also of importance in overcoming any slight tendency to stoppage due to small particles of foreign matter getting into the oil leads.

I had occasion recently to make some tests on how rapidly an electric contact could be made and broken on a revolving disc, which incidentally proved conclusively that a complete oil-film is established by the rotation of the shaft even with a ring-fed bearing. I was using the revolving shaft of an electric motor to drive a disc for making and breaking a circuit to the disc through the frame and shaft of the motor. I suddenly noticed that the current was not reaching the disc and, upon investigation, found that this was due to the fact that the rotation of the shaft had established the oil-film in the bearing, thus breaking the circuit at this point. This brought out very clearly the fact that complete oil-films have been establishing themselves in bearings for many years, whether we have recognized the fact or not, as the motor used in these tests was some 25 or 30 years old.

**MR. ANGLADA:**—In the aviation engine referred to by Mr. Manly the oil is heated to a high degree and loses body or ability to maintain an uninterrupted oil-film. For this reason, an increase of oil pressure was required to float the journals in their bearings, because, with low oil-pressure, the lubricant escaped as rapidly as it was supplied. If the body or viscosity of the oil had been maintained, as by refrigeration, a surprisingly low oil-pressure and, consequently, a slow flow of oil would have proved satisfactory, as has been proved by the innumerable splash-feed engine-bearings that give splendid service when the temperature does not thin the oil excessively.

The point I wish to bring out is that with oil of the proper viscosity, a high oil-feed pressure is not necessary for adequate lubrication. Also, that excessive oil-feed pressure may increase the power loss at the bearings, due to its increasing the work necessary to shear the oil-film on the journal from the oil-film on the bearing.

**MR. MANLY:**—We found that the important requirement was to supply ample oil to each bearing and this was met partly by pumping enough oil and having large enough leads. We also cooled the oil. But it was necessary, in addition, to have a considerable pressure to ensure the proper distribution of the oil to the remotest bearings.

<sup>1</sup> M.S.A.E.—Member of research council, Standard Oil Co. of Indiana, Whiting, Ind.

<sup>2</sup> M.S.A.E.—Consulting engineer, Manly & Veal, New York City.

## “COACHES” AND “BROUGHAMS”

SOME years ago, when the sales-promotion departments of the car builders began to utilize the terms “coach” and “brougham,” they were usually applied to an enlarged coupe having two doors, a full cross seat in the rear and bucket seats in front. Initially, the designation “coach” was applied to a low-priced utility job, and then the word “brougham” found its way into the patter of the sales departments and for the last few years these two words have meant little or nothing because they were used to signify so many different types of body. Today the word “coach” as applied to private-car bodies, has little more than the general significance of indicating a closed body. The Pierce-Arrow Motor Car Co. has lately offered on its “80” chassis a whole series of “custom-built coach bodies” which includes a five-passenger two-

door coach, a five-passenger four-door coach, a seven-passenger four-door coach, and a seven-passenger four-door limousine coach. These new Pierce-Arrow bodies are by no means what is generally regarded as merely “utility” products but are thoroughly in keeping with the high quality of the Pierce-Arrow equipment and appointments. It would seem as if the car builders would have to come around eventually to the S.A.E. Standard nomenclature, as they have created such confusion with their special names that they no longer have significance and have to be explained in each particular line. One company’s “coach” is another builder’s “brougham” and probably still another company’s “two-door sedan,” or it may merely signify a closed vehicle. —Autobody.

## THE FACTORY LABORATORY

EVERY industrial operation presents questions of a scientific nature. Results of value can rarely be obtained aside from extended experiments and practical research. When such experiments are carried out by experts outside of the plant the expense involved is frequently very great. If such experiments are carried out inside of the plant, but without definite aim and correct scientific methods, the results are often misleading. But with a laboratory maintained in the factory, the work of the laboratory is brought into as close relationship as possible with the conditions necessitating the scientific investigation.

It has long been considered that research laboratories to be of any value necessitate a very considerable expenditure of money and require the supervision of a highly paid scientific staff. While in a measure the personnel of such laboratories must be of a high grade of intelligence, it is at the same time possible for one or two skilled research men, with a small clerical and executive staff under their direction, to carry out very extensive programs of research and render a continuous and far-reaching service to every class of industry.

When the size of the industry would limit the entire scientific staff to one well-trained man, he should of necessity be a chemist with as extensive a knowledge as possible of mechanical engineering. With two technical assistants, one a chemist and the other a mechanical engineer, and a stenographer for general clerical work, research laboratories can be maintained at the minimum of expense but with very considerable effectiveness.

When the size of the industry warrants the outlay, it is always wise to subdivide research questions into two groups, namely, physical and chemical. The physical questions usually deal with the purely mechanical properties of the manufactured product, such as strength, elasticity, uniformity of weight and form, and the general ability of the product to sustain the wear and tear for which it was designed. The chemical questions involve more profound research in the direction of atomic composition, deterioration by time and use, and frequently biological questions regarding the effects of mildew, decay or any chemical action that may be started accidentally.

It has been found rather difficult to train one man to have

the insight and attributes of a pure chemist, while possessing at the same time the intensely practical mind of an engineer. Hence, the above subdivision is very desirable in the case of an industry of considerable importance. It is needless to say that these two departments should work in entire harmony with one another while pursuing each its own line of research. One technical assistant for each department, together with a stenographer to be used in common, will be a sufficient staff to carry out very extended programs of experiment and research.

The most successful industrial research laboratories today are those which are equipped not alone for the study of all routine questions arising in a given line of manufacture, but are also able to handle extraordinary subjects that may arise. The objects of industrial research are two-fold. Primarily, the manufactured product is produced of better and more uniform grade and at less expense when safeguarded by thorough inspection and test. Secondly, a much more uniform and satisfactory grade of raw materials, such as coal, oil, water, fiber, chemicals, and general supplies for the plant can be secured when it is known in advance that these commodities will be subjected to a rigid test and refused if undesirable. A research laboratory should, therefore, include in its scope the testing and standardization of every known and expected material that goes into the make-up of a given manufactured article.

In the physical laboratory, equipment should be provided for complete tests upon the mechanical properties of all materials and manufactured products. The chemical laboratory should handle all questions of analysis, reaction and chemical properties and relations.

As a provision for future extension, a well-equipped laboratory should provide lighting and industrial alternating and direct electric currents of various voltages, compressed air at any adjustable uniform pressure desired, hot and cold tap water of fair purity, distilled water for refined operations and illuminating gas for heating as well as lighting. Added to this should be portable oxygen tank service for experiments in combustion.—From a paper by G. B. Haven presented at the annual meeting of the American Society for Testing Materials.

## UNITED STATES POPULATION ALMOST 116,000,000

THE population of Continental United States totaled 115,940,000 on Jan. 1, 1926, according to estimates by the National Bureau of Economic Research. This is an increase of 1,629,000 over the estimate for Jan. 1, 1925, and shows a population gain of more than 10,000,000 since the United States census was taken at the beginning of 1920. As it happens, the indicated gain for the year 1925 was almost identical with that for 1924. A moderate decrease in the net migration to the United States was recorded, but this was offset by a larger number of births and a smaller number of deaths. The total population gain in 1925 was slightly larger than the average for the last 17 years but materially less than that of 1923, when the large volume of immigration contributed to a population increase of 1,996,000, or of 1909, when, for the same cause, the population growth ran up to 2,173,000.

In the last year, immigration played but a minor role in the population growth of the Country, accounting for less than one-sixth of the total increase, the excess of births over deaths adding 1,367,000 persons, while immigration accounted

for but 262,000 new inhabitants. It is a remarkable fact that, despite the great growth in the population of the Country, both the number of births and the number of deaths were approximately the same in 1925 as in 1909.

### LARGE NON-QUOTA IMMIGRATION

Of the 262,000 net gain in population from migration in 1925, Americans returning to the United States made up 10,000 and aliens 252,000. Of these latter, 43,000 were classed as non-immigrant aliens and 209,000 as immigrant aliens. The annual legal quota of immigration is at present only 165,000, hence we gained 87,000 more aliens than allowed for by the quota. When the fact is considered that the gross immigration from American countries to which the quota does not apply was 170,000 this excess is easily explained. At present, the bulk of the European immigration is coming from the British Isles and Germany, the inflow from Southern and Eastern Europe, as might be expected from the operation of the law, being far less than before the present restrictions were imposed.



# The Motorcoach and the Railroad

AUTOMOTIVE TRANSPORTATION MEETING PAPER

By H. F. FRITCH<sup>1</sup>

THE discussion following the presentation of this paper at the Automotive Transportation Meeting of the Society that was held at Philadelphia in last November was entirely oral, no written contributions having been received. In accordance with the usual practice, the stenographic report of these remarks has been submitted to the various speakers for their approval and to the author for any additional comment that he cared to make. The corrected discussion, as received, is printed below. An abstract of the paper precedes the discussion so that those of the members who did not read the paper when it was printed in the December, 1925, issue of THE JOURNAL can gather some knowledge of the subjects covered by reading the abstract if they do not wish to read the complete text.

## ABSTRACT

MOTOR vehicles have become an important factor in the affairs of the railroads. In 1920, which was the peak year, the total number of passengers carried by the railroads of the Country was approximately 1,269,913,000, while in 1924 the number was approximately 931,348,000, a decrease of 27 per cent. This decrease was not entirely due to the private automobile but to some extent to the motorcoach.

The particularly acute situation is that branch-line revenues have been so depleted by the automobile and the motor truck that the main lines can no longer support these branch lines and more economical transportation must be found. The substitution of motor-vehicle service in such instances for steam-train service rather than the abandonment of all service will be to the advantage of the railroad, since it will make possible the continuance and probable increase of the industrial and social activities of the communities served by the branch lines so that they will not be lost as feeders to the main lines.

In an effort to solve this problem in the territory that is served by the Boston & Maine Railroad, a subsidiary, the Boston & Maine Transportation Co., was organized. Since last May this company has inaugurated a number of services of various types. These include motorcoach service at Portsmouth, N. H., as a substitute for the electric street railway that was discontinued; the substitution of motorcoach service for steam on a 12-mile line between Portsmouth and York Beach, Me.; an interstate line between Boston and Portland, Me., and the use of motorcoaches in the summer resort districts of New Hampshire to supplement steam-train service. At the height of the summer season eight distinct motorcoach services covering 445 miles were in operation. All of these various services and the results obtained are described in the paper. A fleet of 30 motorcoaches of two distinct types were used for these various services, 18 being of the so-called street-car type and 12 of the parlor-car type. In practically all of these motorcoaches double-depth individual cushions are used. Both types of motorcoach are described and illustrations of both the interiors and the exteriors supplement the text.

The paper discusses the possibilities of standardizing motorcoach design and the point is emphasized that the greatest demand for variation from standard practice is in the construction of the body rather than in the

chassis. Among the other points touched upon are the use of proper springs, the improvement of brakes as regards effectiveness, the necessity for providing sufficient aisle and seating space, the selection of outside body sheathing and painting.

## THE DISCUSSION

F. C. HORNER<sup>2</sup>:—I should like to compliment Mr. Fritch on having delivered an excellent paper and the Boston & Maine officials for their very constructive accomplishments in the short time they have been working on this problem of the coordination of railroad and motorcoach operation. About 1½ or 2 years ago I had a talk on this subject in Boston with Mr. Lorning, of the Boston & Maine Railroad, and he said,

I know very little about this problem but we intend to look at it in a constructive way and find out what use can be made of the motor vehicle in the railroad business.

That in my opinion is the only attitude to take if we are to make any progress in fitting this new tool into the transportation business of the steam and electric railroads.

It is not entirely clear in my mind whether or not the motorcoach operations of the Boston & Maine Railroad are carried on by the Boston & Maine Transportation Co. or the Boston & Maine Railroad direct.

As we are likely to be misguided unless we have the whole picture, I should like to ask what percentage of the riders in the motorcoaches filled in answers to the questionnaires that Mr. Fritch mentioned and whether 23 per cent is not a large volume of new business. If 77 per cent replied that they would have ridden on the rails, I assume that the 23 per cent might have ridden in some other way if the motorcoaches had not been placed in operation.

Also, I should like to ask if Mr. Fritch believes that the Interstate Commerce Commission should control interstate carriers and the State commissions the intrastate carriers.

## BAGGAGE HANDLING AND BODY STANDARDIZATION

With reference to his remarks on standardization of chassis and body, what is done usually when trunks are to be carried? Has any attempt been made to use a light truck to supplement the operation of motorcoaches in a given service, and, if so, has it been found that this can be done to advantage? A number of railroads are considering the possibility of using motorcoaches, and the handling of baggage is one problem that is involved with the whole subject. In certain cases that are being studied some doubt exists as to whether a supplementary baggage service by truck would meet the requirements economically and otherwise.

Mr. Fritch made an important point with respect to special bodies retarding standardization and keeping the cost of construction high. If the builders did everything that the users of the vehicle want them to do, they could not furnish the equipment at a reasonable figure. On the other hand, many of the recommendations or requests for changes in construction, especially in bodies, are constructive and helpful, if the designing engineer or

<sup>1</sup> President, Boston & Maine Transportation Co., Boston.

<sup>2</sup> M.S.A.E.—Manager railway transportation department, General Motors Corporation, New York City.

the engineering department has the vision and judgment to carry out the requests wisely. All who are familiar with the subject and close to their own engineering departments probably know that a great many engineers are hard to sell on a proposal to make any changes in anything they have designed. Some engineers, however, study the requirements carefully, and, after all, the acid test is whether or not a vehicle meets the requirements. However, it is necessary to build to the actual requirements in the field but certainly not to the whims and fancies of everyone asking for special this, that and the other.

Two other questions that I should like to ask Mr. Fritch are: Does he regard a four-cylinder or a light six-cylinder engine as better for a street-car type of motorcoach, and, in his operation, what size of tires show the best economy on (a) the street-car type and (b) the intercity type of vehicle.

**MR. FRITCH:**—We have only one motorcoach that is operated by the Boston & Maine Railroad, and that will be taken over by the Boston & Maine Transportation Co. as soon as the license is formally transferred. Twenty-nine out of 30 coaches are operated by the transportation organization. Our policy is to conduct the motorcoach activities through the transportation company, which is not owned by the Boston & Maine Railroad but is organized to function absolutely in its interest.

Regarding the replies to the questionnaire, the reason I stopped at 77 per cent is that we are not interested in boat lines. A good boat line runs between Portland and Boston and a large percentage of the coach passengers above 77 per cent said that they would have traveled by boat. It did not make much difference to us so far as that was concerned, but if the percentage who would travel by boat should be added to the percentage we have, the difference would be insignificant. The volume of new business in addition to those who stated that they would have gone by rail or boat was very small. A very large percentage of the passengers were willing to and did fill out the questionnaires during the period of 2 or 3 weeks that we distributed them.

#### REGULATION BY STATE COMMISSIONS PREFERABLE

As to the Interstate Commerce Commission or the State Commissions, I suppose the simplest arrangement would be to have the Interstate Commerce Commission regulate the operations, but that Commission is a much overworked body. No doubt many of the State Commissions are, too, but I feel sure, from what I have heard, that the Interstate Commerce Commission is very reluctant to take over this large mass of additional regulation, and I have heard intimations that it is very willing to have the power delegated to a certain extent to the State Commissions, the Interstate Commerce Commission taking part only when a dispute between neighboring States might arise. I feel that such an arrangement would be satisfactory, because the operators would have the advantage of close touch with the State Commissions rather than the more distant Interstate Commerce Commission, with a referee in case of a dispute.

We have no equipment to handle trunks. We have carried a small quantity of baggage by motorcoach but when we handle other than hand baggage we charge for it in addition to the charge for the passenger. A large quantity of baggage was involved on the York Beach line, as travelers going to the hotels had whole truck loads of trunks. In that case we made no attempt to

handle baggage on the motorcoaches but made a contract with a local man to transfer the trunks for the passengers by truck. Our only interest in the matter was to secure as low a rate as we could in the interest of making the motorcoach operation successful. Whether or not it was financially profitable for the truck operator I do not know; he said it was not but I suspect from appearances that it was.

I am not prepared to say that either the four or six-cylinder engine is preferable for the operation of street-car-type motorcoaches to the exclusion of the other type of engine. We have been operating both very successfully. A longer time than we have had is necessary, I feel, to settle that question.

The most economical size of tire depends upon the size of the vehicle and the speed at which it is operated. I can state emphatically that it is necessary to be extremely careful in equipping motorcoaches that are to be operated over long distances at fairly high speeds as compared with the speed of the average passenger-vehicle. If the tires are too small, trouble certainly will be encountered. I am not prepared to assert whether a 32 x 6 or a 36 x 6-in. tire is the best; probably nobody knows, but I am absolutely satisfied from our own experience that the smaller-sized tire for the usual de luxe motorcoach is not adequate. The smaller size may serve for the city type except in a city where loads are very heavy, which is not our case at all. For our small-city and suburban operations tires such as the 32 x 6-in. size are giving good service.

#### NOT CONSIDERING CONVERTING ROADBED TO HIGHWAY

**A MEMBER:**—Is the Boston & Maine Railroad considering altering the roadbed to permit motorcoaches to operate in its private right-of-way?

**MR. FRITCH:**—We have had many suggestions along that line, such as planking-over or surfacing so as to retain the rails and also have a road for motor vehicles, but we are not considering the development of the roadbed as a highway. Undoubtedly at some places in our territory, by converting our roadbed into a highway of easy grades without sharp curves, it can be developed as a cut-off in place of the existing highway, but most of the places where we are operating and where we probably will operate to the greatest extent are in rather sparsely settled territory where the highways, so far as their physical dimensions are concerned, are capable of absorbing considerably more traffic than they have today. That is very different from conditions in Connecticut, where the traffic density is much greater. In our territory we do not feel that auxiliary highways are necessary except in very special cases.

#### PROPOSED PLAN FOR STANDARDIZATION

**G. C. HECKER:**—Apparently the standardization problem has a number of different phases. Speaking from the viewpoint of the electric-railway operator of motorcoaches, I should say that one of the reasons that standardization is particularly desirable is to reduce the first cost of the vehicle. A second reason is to enable the operator to standardize on maintenance and the supply of spare parts.

I have been informed from reliable sources that the cost of the average motorcoach could be reduced \$1,000 or \$1,500 if a reasonable degree of standardization in design could be brought about. A proposal toward standardization that seems to be gaining favor in the minds of certain electric-railway operators is that each builder develop perhaps two or three standard types of motor-

\* Special engineer, American Electric Railway Association, New York City.

coach and offer those to the purchaser at certain prices that obviously would have to allow for a reasonable profit. Then, when a man wants a design that is different from any of the standards, let him pay extra for every variation he demands. Furthermore, let it be agreed that no one will suggest a change for a period of 6 months and that for another period of 6 months no change will actually be made but that, in that second period, suggested changes will be considered and a decision reached as to whether or not they are desirable. That would give the builder a year for production on standard models and he should be able to offer a more attractive price to the purchaser of the standard models than on some special job.

#### ELECTRIC LINES HAVE GAINED TRAFFIC

I was interested in the statement by Mr. Fritch that the private automobile and, to some extent, the motorcoach have reduced the passenger traffic of the steam railroads by 27 per cent since 1920. It may be of interest to know what has happened during a somewhat similar period in the electric-railway industry. In 1924 the electric railways carried approximately 16,000,000,000 passengers, which is an increase of about 2,000,000,000 in a period of 10 years. The traffic on the electric railways has increased during this period of tremendous growth in the use of the private automobile and in the initial period of the development of motorcoach operation.

Mr. Fritch also spoke about the hesitancy of the established carriers to enter an apparently untried field. That has been true in the electric-railway industry and the operators have been criticized to some extent because they did not go into motorcoach operation more rapidly than they did. However, 16 electric-railway companies were operating a total of 75 motorcoaches over a few miles of route in 1920, and the latest figures we have indicate that 251 electric railways were operating 4452 motorcoaches over 12,060 miles of route in 1924. Figures that we have collected at the headquarters of the American Electric Railway Association indicate that approximately two-thirds of these operations are unprofitable and presumably will be for some time, although in general the business is increasing at a rate that undoubtedly will make a number of the operations profitable. That is due perhaps to a large extent to the fact that many of these operations were started in sparsely settled territory to extend existing railway service in the most economical way possible and also where competition had been threatened. They were not started with the idea of making immediate profits, because it was recognized that at the outset they would not pay.

#### STANDARD COST-ACCOUNTING SYSTEM ADOPTED

The Accountants Association of our American Electric Railway Association adopted a standard cost-accounting system for motorcoach operation at its convention in October, 1925. This is to be reprinted and distributed to all of the electric-railway companies in the Country and will be available to anyone else who wants it. Copies will be sent also to the various regulatory bodies for their information. It is our hope that this will bring about standardization of accounting so that comparison of the operating results on different properties can be made. Operating results are not comparable at present in the majority of cases; one must be very careful in comparing the figures of one operation with those of another.

With regard to the regulation of interstate-motorcoach common-carriers, I believe that the National Automobile Chamber of Commerce, the steam railroads, the electric railways, and everyone else who is interested in the subject are getting together to introduce into the Congress at an early date a bill to place this regulation in the hands of the existing State regulatory bodies and possibly providing that the Interstate Commerce Commission shall act as arbiter when the State Commissions are unable to agree. I believe that it is very desirable to retain the regulation in the States. I think that operators, particularly men who are preparing to start motorcoach operation on a small scale, would find it inconvenient and expensive to go to the City of Washington to attend hearings, and it would take much of their time. It would be much simpler, I think, for the States to have charge of the regulation and, when several States are involved and an agreement cannot be reached, to refer the question to the Interstate Commerce Commission.

#### PROBLEMS OF REGULATING MOTORCOACH OPERATION

R. E. PLIMPTON<sup>4</sup>:—I think the average operator who is now engaged in interstate operation would be very willing to have the situation left as it is. He seems to be getting along and, while evils such as competition, cut rates and duplication of service, exist he nevertheless thinks that he is making some money.

Just before leaving New York City I made a little survey to learn what the conditions were there and, although this was taken 3 days ago, it probably is out-of-date today because, in spite of the beginning of cold weather, operators seem to be starting new lines every day or two. We found that more than \$1,000,000 worth of equipment had been placed in service in New York City since early in the spring. The United States Supreme Court decision, which came out in March and to which Commissioner Stoeckel referred in his paper at this session, was based upon a suit started in the State of Washington and another one in Maryland, but it took 3 or 4 months for operators to realize that the gates were open and to take advantage of the summer business. More than 100 motorcoaches are running into New York City and they serve 22 different communities; this does not include the towns and cities that they go through enroute.

About half of these operations are not of the type that usually are regulated by State authorities; they are purely local services in the Metropolitan District. I am not making any suggestion as to the kind of law that is needed to cover this condition but I think it is important to realize that in the matter of legislation we are not considering merely the long-distance interstate operation. A considerable part of the service in New York City and other places is local and very often the city has been granted home rule by the State legislature to control transit matters. That would need to be taken care of in any new law.

I think that, in the interest of good transportation, passenger services over the highway cannot be separated permanently. If one law is to be enacted for intrastate operation and another for interstate operation, it will mean that very often the services will be operated by separate companies and that the tendency toward evasion of the law will be constant. That situation will be remedied in time by economic forces but at first some companies will obtain interstate permits and others will secure intrastate permits for what amounts to the same routes when they can do so. Trans-

<sup>4</sup>M.S.A.E.—Associate editor, *Bus Transportation*, New York City.

portation men will agree with me, I think, that to try to run two such lines over the same route is not sound practice or to have an interstate service running over the highway and not furnish intrastate service of the same sort over the same highway.

#### A BALANCED STRUCTURAL TRIANGLE

**M. C. HORINE**<sup>5</sup>:—What has been Mr. Fritch's experience as to the best place to carry baggage? He mentioned two methods, that is, carrying hand baggage on the roof and carrying it in the body. How is it carried in the body? Should the driver be enclosed in a small compartment shut-off by curtains or should he be separated from the passengers merely by a railing? What maximum speed is practicable in intercity operation? How does the Boston & Maine Transportation Co. handle the smoking problem on long-distance lines? Are window drapes on parlor cars practical in commercial transportation? What is the proper head-room for a parlor car? Is there any likelihood that parlor cars of the future will have city-type head-room or will the low roofs now in vogue remain?

In mentioning a few of the things which the operator wants and which the builder apparently is not giving him, Mr. Fritch expressed a sort of trinity. He said we should have more comfortable springs, more adequate tires and, at the same time, a low floor. That is a triangle one side of which cannot be increased without reducing another. If we are to have easier springs we must have more spring deflection, which means a higher floor. If we are to have more adequate tires, the tires must be larger and that means a higher floor or, with a given floor height, less spring deflection. Which of these three sides of the triangle is most important? Do we want a compromise, which is about what we now have, or do we want to sacrifice a little as regards the low floor in favor of greater spring deflection, or shall we leave the springs as they are and put on larger tires?

#### BAGGAGE SPACE, SPEED AND HEAD-ROOM

**MR. FRITCH**:—I will not say that we have found exactly the proper place for baggage but I am satisfied that it is inside. We have no motorcoaches in which hand baggage is loaded through the rear of the body but I have seen vehicles of that character that appealed to me very much. It is possible to secure considerable space behind the slanting backs of the rear bank of seats. The baggage space that we use primarily for trunks has served nicely for hand luggage in addition.

<sup>5</sup> M.S.A.E.—Sales promotion engineer, International Motor Co., New York City.

<sup>6</sup> M.S.A.E.—Vice-president and superintendent, Hoopes Bros. & Darlington, West Chester, Pa.

Of course, it is extremely adequate, but that space is not in the regular de luxe type of motorcoach but more in the street-car type.

I am not in favor of the driver being enclosed.

The maximum speed in intercity service depends very much upon where the cities are and what lies between them. In certain parts of our territory the motorcoaches probably could run 45 m.p.h. and not be in nearly so much danger as in other parts of the same route if going 20 m.p.h. Conditions vary too much for me to undertake to make a flat statement that any definite speed is the maximum or proper speed for intercity operation.

I do not feel that it is necessary to have sufficient head-room for passengers to stand upright in a motorcoach that is to be used exclusively in intercity operation. I do not recall the exact head-room in our parlor-car type motorcoaches, which seems to be adequate for that type of service, but we have operated that same type of vehicle on a semi-intercity run where it would have been very desirable and have saved considerable embarrassment if the passengers could have stood upright. If two or three passengers are obliged to stand for a short ride, it is very awkward to do so in a motorcoach with a low roof. I believe the tendency will be toward a composite body. A body of the parlor-car type having full head-room possesses advantages for operations in which the coach probably will be used in a composite service. Very attractive bodies of that character can be built.

#### MUST COMPROMISE ON DESIRED CHARACTERISTICS

Mr. Horine is absolutely correct as to floor height, springs and tires; that triangle exists. Probably we cannot have all three to the extent we should like to have them but, speaking from our own experience, we have motorcoaches that, with tires of reasonably large size and with reasonably adequate spring action, could have a reasonable floor height. Of course, we cannot have an extremely low floor and very large tires; a balance of the three desirable characteristics must be struck.

**RUSSELL HOOPES**<sup>6</sup>:—What is your experience with dual pneumatic tires? Is there any undue heating of the inside tire?

**MR. FRITCH**:—We have had heating, not only of the inside but of the outside tires, due mainly to their small size.

**MR. HOOPES**:—Does not the brake action cause heating of the inside tire?

**MR. FRITCH**:—The heating was caused principally by the brakes but it affected both tires.



# Chassis Lubrication

By FRED H. GLEASON<sup>1</sup>

MILWAUKEE SECTION PAPER

Illustrated with DRAWINGS

## ABSTRACT

GREATER length of chassis-life, improved riding and handling qualities and the elimination of annoying squeaks and rattles are the major benefits sought in chassis lubrication, and these are claimed to be achieved by an effective system which derives its lubricant from a central source. The paper supplements a previous one, and is in the nature of a progress report. Experimental work since that of 1924 is described, and the improvements in the system resulting therefrom are cited. Layouts and constructions used in connection with this central-source chassis-lubrication system are illustrated, and a short description of the salient points is presented.

Oil pressures maintained in the different parts of the system are discussed, possible leakages of the oil are specified, desirable viscosities of the oil are mentioned, and the construction of the tubing and the various special connections is explained. The lubrication of special parts of the chassis is also covered. Field results show that the best lubrication is attained by use of the heavier grades of engine cylinder-oils which have great viscosity.

THE incorporation of a central-source lubrication-system in the chassis of either a passenger or a freight transportation-vehicle relieves the operator of the major portion of the work necessary to maintain the vehicle in proper operating-condition. Efficient lubrication of the various chassis-bearings results in longer chassis-life, improved riding and handling qualities and the elimination of annoying squeaks and rattles. The many advantages resulting from central-source chassis-lubrication have been recognized by the adoption of such systems by nine different builders of automobiles in the last 2 years. Before describing the chassis-lubrication system manufactured by the corporation with which I am connected, types of system developed in connection with our experimental work will be described.

Fig. 1 shows a chassis-lubrication system supplied with oil under pressure taken from the oil lubrication-system of the engine. Details of the valve controlling the flow of oil from the engine system to the chassis system and of the oil controls at the outlets are shown in section in the upper part of Fig. 1. A self-closing needle-valve installed on the instrument board of the car is connected to the engine system and to the chassis system, comprising a single tube extending around the chassis with tee and elbow controls located at each point lubricated. The controls were provided with one or more felt plugs forced into a recess in the control fitting, the volume of oil supplied to each point being approximately controlled by the thickness or number of felt plugs in the fitting. A pressure-gage was installed on the dash in conjunction with the control valve, the gage being connected to the chassis system at a point remote from the source of oil supply. The system was operated by holding the control valve open until the gage indicated by showing pressure that the chassis system was filled with

oil. Under pressure, oil was forced through the felt plugs to the bearings and, when the pressure was relieved, a slow percolation of oil through the felt supplied oil for a considerable time-period. The table below Fig. 1 shows the actual Fahrenheit temperatures developed at points *a*, *b* and *c*, on a chassis, after the car had been in operation for a period under various seasonal temperatures. The car was provided with an automatic shutter on the radiator. A variation of 40 deg. Fahr. between points *a* and *b* is developed on the average chassis.

Fig. 2 shows improvements made on the system shown in Fig. 1. The sectional view at the upper left shows a control device, placed in the connection between the

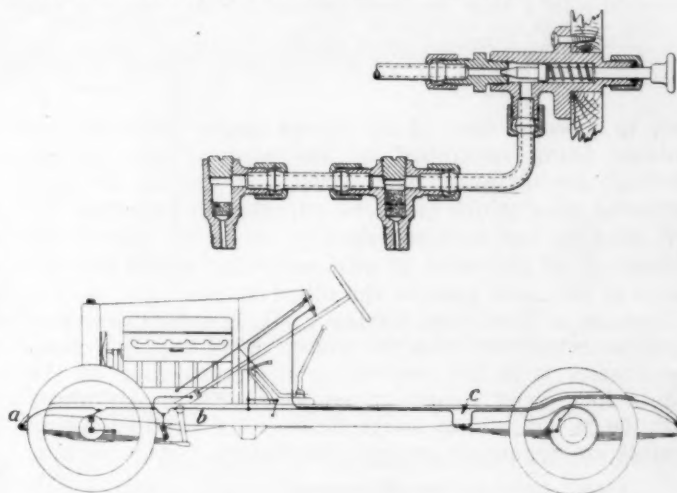


FIG. 1—CHASSIS LUBRICATED WITH ENGINE OIL UNDER PRESSURE

This Chassis-Lubrication System Is Supplied with Oil under Pressure, Taken from the Lubrication System of the Engine. In the Upper Part, Details Are Shown of the Valve Controlling the Flow of Oil from the Engine System to the Chassis System and of the Oil Controls at the Outlets. A Self-Closing Needle-Valve Installed on the Instrument Board Is Connected to the Engine System and to the Chassis System. Each Control Is Provided with One or More Felt Plugs Forced into a Recess in the Control Fitting, the Volume of Oil Supplied to Each Point Being Controlled by the Thickness or Number of Felt Plugs in the Fitting. A Pressure-Gage Is Installed on the Dash in Conjunction with the Control Valve. The Following Table Shows the Actual Temperatures Developed at the Points *a*, *b* and *c* on a Chassis during Operation for the Periods Specified

Condition under Which Car Operated	Time Car Operated		Points		
	Hr.	Min.	<i>a</i>	<i>b</i>	<i>c</i>
With Radiator Shutter	—	—	20	80	50
	1	—	10	60	54
	—	30	26	60	46
	—	15	1	40	24
	—	15	14	15	28
	—	15	30	60	44
Without Radiator Shutter (Summer Operation)	1	—	74	110	90
	—	15	70	105	84

engine system and the chassis system, which transfers a measured volume of oil under pressure to the chassis system each time the valve is operated. The lower assembly shows the details of a system similar in general operation but supplied with oil from a dash reservoir through a spring-operated dash-pump provided with check valves between the reservoir and the pump and between the pump and the chassis system. The controls were improved by adding check valves at the out-

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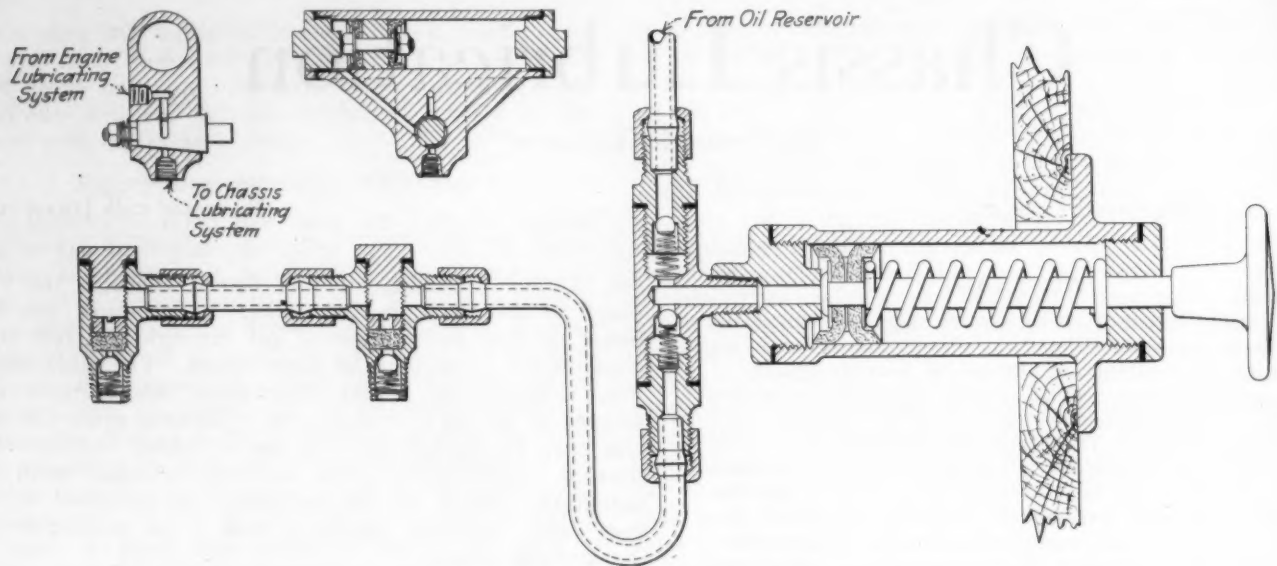


FIG. 2—IMPROVEMENTS ON THE SYSTEM SHOWN IN FIG. 1

The Sectional Views at the Upper Left Show a Control Device, Placed in the Connection between the Engine System and the Chassis System, Which Transfers a Measured Volume of Oil under Pressure to the Chassis System Each Time the Valve Is Operated. The Lower Assembly Shows the Details of a System Similar in General Operation But Supplied with Oil from a Dash Reservoir through a Spring-Operated Dash-Pump Provided with Check Valves between the Reservoir and the Pump and between the Pump and the Chassis System. The Controls Were Improved by Adding Check Valves at the Outlets To Prevent Flow of Oil Except under Pressure, the Volume Being Controlled by the Size of the Passage through the Fitting at Each Outlet and Also by Adding a Threaded Plug That Can Be Adjusted To Compress the Felt Plug to Any Required Density So As To Control the Volume of Oil Delivered at Any Particular Outlet As Compared or Balanced against the Other Outlets

lets to prevent flow of oil except under pressure, the volume being controlled by the size of the passage through the fitting at each outlet and also by adding a threaded plug which could be adjusted to compress the felt plug to any required density, so as to control the volume of oil delivered at any particular outlet as compared or balanced against the other outlets.

Systems of this type, having a single continuous supply-tube extending from the source of oil supply around the chassis with the controlling devices located at the points lubricated require from 45 to 85 ft. of tubing with 50 to 80 tubing connections, some sections being flexible or requiring swivel connections. Any serious

leak in any of these connections will affect the proper operation of the system materially, and a break in any part of the system will render the complete system inoperative. Variations of temperature in different parts of this type of system cause variations of the viscosity of the oil in the system and since control of the volumes delivered is obtained by balancing the resistances at the outlets against each other, variations of the viscosity and, hence, the fluidity, will affect the balancing of resistances of the outlets and influence the performance of the system. Variations in the fit or resistances of the bearing supplied affect the distribution of the oil.

Fig. 3 shows an oil-measuring delivery-control developed in connection with our experimental work. A tee casting with a through tubing-connection has a cylinder with a loose-fitting piston supported against a stop by a spring. This piston, when forced to the bottom of the cylinder, is seated against a circular raised-seat, the outlet passage being provided with a check valve as shown. When oil under pressure is forced through the supply tube, the piston is forced down in the cylinder. The oil below the piston passes out through the check valve in the outlet. The piston, seating at the bottom of the cylinder, prevents any flow of oil under continued pressure in the supply tube. After the release of the pressure in the supply tube, the spring returns the piston to its top position against the stop, the space below the piston being filled with oil from the supply tube passing the clearance between the piston and the cylinder and the check valve at the outlet preventing any return of oil or air from the delivery passage. The volume of oil delivered at each cycle is controlled accurately by the piston travel. An adjustable stop, shown at the right in Fig. 3, can be used to regulate the volume of oil delivered.

Two single controls, and a triple control connected in a supply line and to a combined reservoir and pump constitute a device that will operate very satisfactorily and will measure and deliver accurately any volume of oil within its capacity. The balanced relation that exists between the piston spring-pressure, clearance between the

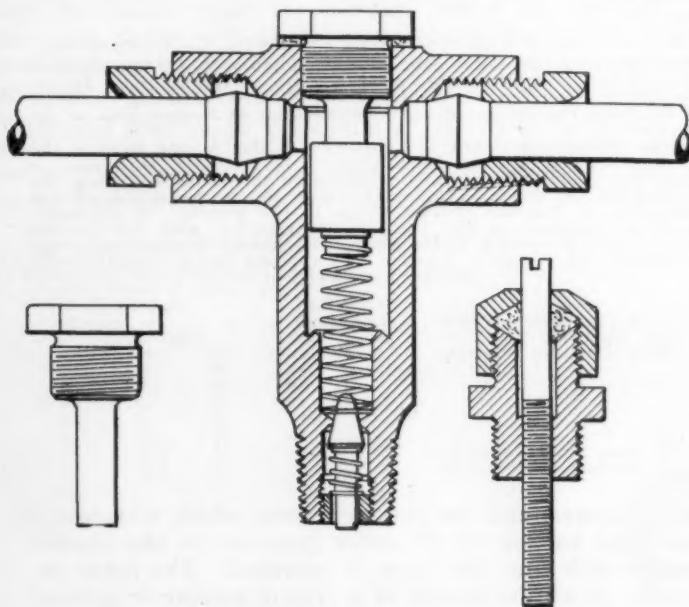


FIG. 3—OIL-MEASURING DELIVERY-CONTROL

A Tee Casting with a Through Tubing-Connection Has a Cylinder with a Loose-Fitting Piston Supported against a Stop by a Spring. This Piston, When Forced to the Bottom of the Cylinder, Is Seated against a Circular Raised-Seat, the Outlet Passage Being Provided with a Check Valve As Shown

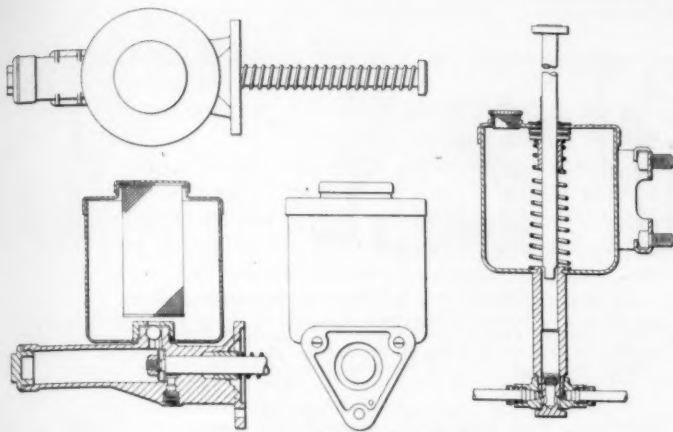


FIG. 4—RESERVOIR PUMP

A Sectional View of the Pressed-Metal Reservoir-Pump for Installation on the Dash and for Foot Operation Is Illustrated in the Left Half, and a Similar Pump Adapted for Installation on the Chassis Frame Is Shown at the Right

piston and the cylinder and the necessary rate of pressure rise in the supply tube to operate this control properly is very difficult to attain, especially when 40 or 50 con-

the chassis frame. This pump is operated by depressing the plunger, which traps oil in the cylinder and forces it through the screen at the bottom of the cylinder into the main supply tubes of the primary system. The pump should be installed so that it always maintains a head of oil on the outlets. The left portion of Fig. 4 shows a reservoir pump adapted for installation on the dash and for foot operation. Depressing the plunger closes the ball check-valve between the reservoir and the cylinder and forces the volume of oil displaced by the plunger out through the passage at the bottom into the main supply-tubes. A spring returns the plunger to the position shown, the leather washer on the plunger-end sealing the outlet port and preventing oil seepage through the plunger gland-packing during idle periods. Any oil passing the gland is dropped clear of the dash through the hole in the attaching flange. The reservoir has a removable screen of 70 x 70 mesh, and the cylinder intake above the bottom provides a sediment space for any dirt that may pass the screen. The reservoir and cover are drawn-steel shells which will withstand hard usage without becoming deformed or developing oil leaks.

The measuring-delivery control or header which regu-

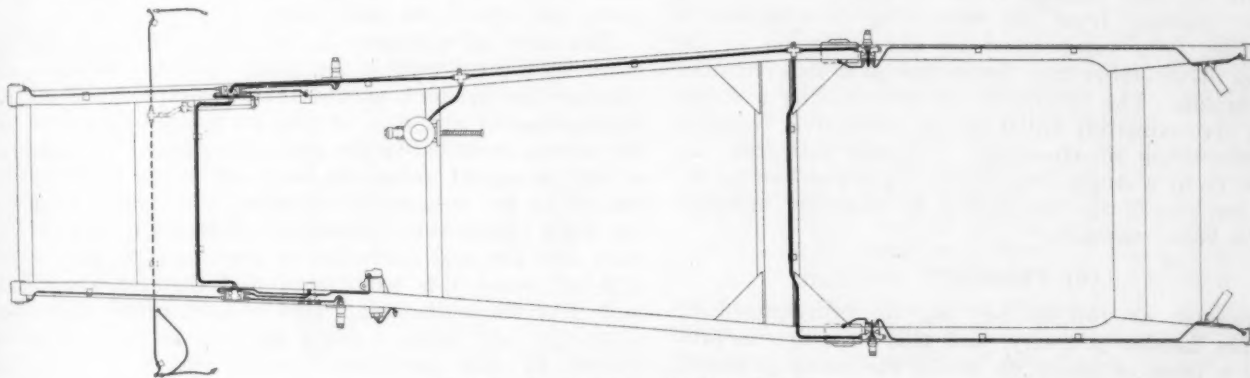


FIG. 5—CHASSIS-LUBRICATION LAYOUT

This Drawing Indicates How the Front Axle, the Drag-Link, All Spring-Bolts, and Brake Rockers Are Lubricated

trols are assembled in a single system. The foregoing balanced relations are also affected by the viscosity of the oil that is to be controlled. This type of control will function satisfactorily regardless of the temperature conditions, the only noticeable effect of operation at low temperatures being an increased pressure required in the supply tube and a longer time-interval required for the control to reload for another cycle. The greatest defect of this type of control is due to the small clearance required between the piston and the cylinder for proper operation. The smallest particle of metal or dirt catching between the piston and the cylinder-wall will wedge the piston at the bottom of its stroke and prevent proper operation. Another defect resulted from occasional leaks in the outlet check-valve, which allowed oil or air from the outlet passage to return to the space below the piston and prevented proper reloading of the cylinder for another cycle.

#### CENTRAL-SOURCE CHASSIS-LUBRICATION LAYOUTS

The following illustrations show material, layouts and constructions used in connection with installations of our central-source chassis-lubrication systems. Most of these illustrations are self-explanatory and only a short description of the salient points is given.

The drawing at the right of Fig. 4 is a sectional view of the pressed-metal reservoir-pump for installation on

lates the volume of oil supplied to each point lubricated is similar to that described in our previous paper<sup>2</sup>. Each outlet is provided with a passage having spaced valve-seats between which a double-ended valve with tapered ends is adapted to operate. This valve is held closed against the oil-inlet passage by a spring. An air-chamber formed from a single piece of metal is attached to the header over the valve chamber by a threaded portion and made oil-tight with a gasket. A header tubing-connection combining the outlet-valve seat and delivery-tube connection is attached by a threaded portion and made oil-tight with a gasket. In production, the valve is

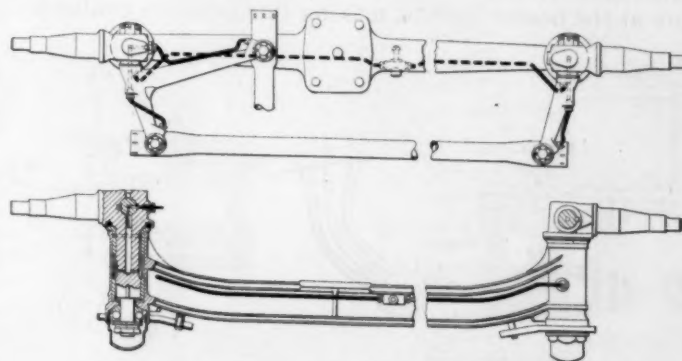


FIG. 6—LUBRICATION OF A FRONT-AXLE ASSEMBLY  
How Lubricant Is Supplied to the Knuckles and the Ball Studs of the Steering-Rods Is Indicated in This Illustration

<sup>2</sup> See THE JOURNAL, April, 1924, p. 424.

seated by assembling the header tubing-connection in the valve passage with the valve in place. The tapered ends of the valve are forced into the softer metal of the header body and the outlet connection, forming seats approximately  $1/64$  in. wide. The outlet connection is then removed and replaced with a copper gasket  $1/32$  in. thick, automatically adjusting the valves for a uniform end-travel of  $1/32$  in. In multiple-outlet headers, a common supply-passage is provided with as many outlets as are required. Headers are machined from brass forgings or castings, but headers made from die castings will be in production shortly. Practically any combination of inlets and outlets can be supplied to meet the requirements of any installation.

Operation of the pump plunger forces oil under pressure through the primary supply-tube to the header. This oil, under pressure, operates the header valve, opening the inlet passage from the pump to the measuring air-chamber and closing the outlet passage to the bearing; oil then flows up into the measuring air-chamber, compressing the trapped air. Release of the pump plunger allows the pressure to drop in the primary supply-tube and the header valve is returned by action of its spring closing the oil-inlet passage from the pump and opening the outlet passage from the measuring air-chamber to the bearing. The compressed air above the oil in the measuring air-chamber then forces the oil in this chamber to the bearing. The volume of oil delivered by a single outlet is approximately equal to the volumetric capacity of the measuring air-chamber. Volumes delivered can be varied from a single drop to any required volume by varying the size of the measuring air-chamber installed above the valve passage.

#### OIL PRESSURES

Oil pressure of 150 lb. per sq. in. is required to operate the header properly, and this pressure is produced by a push of about 30 lb. on the pump plunger. Pressures ranging from 300 to 1000 lb. per sq. in. are developed normally in the primary supply-tubes of the average installation, depending on the type of pump used and on the physical effort exerted by the operator. This range of pressure beyond that required to operate the header provides a large factor of safety to assure proper valve-operation and delivery of the oil to bearings; also, it secures proper operation at low temperatures, since the loading of each individual outlet of the header is accomplished under high pressure through large supply-tubes and passages.

Pressures developed at the header outlets with one stroke of the pump plunger vary from 1 to 100 lb. per sq. in., depending on the volume of oil delivered. Several consecutive strokes on the pump will develop pump pressure at the header outlets, making this pressure available

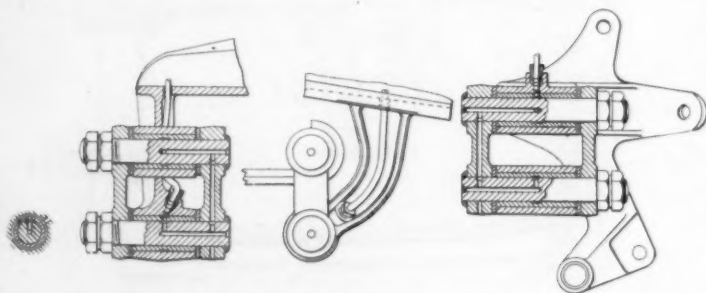


FIG. 7—LUBRICATION OF SHACKLE-ASSEMBLIES  
The Method Employed To Lubricate a Tension Shackle-Assembly Is Indicated at the Left, and That for Lubricating a Compression Shackle-Assembly Is Shown at the Right

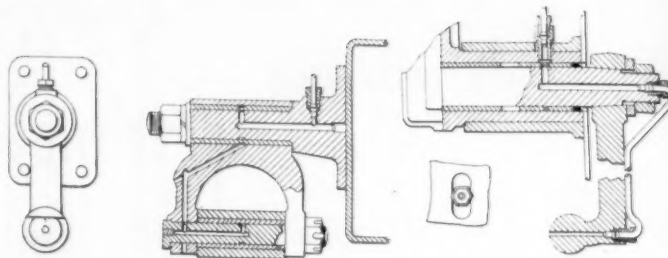


FIG. 8—OTHER SPECIAL MEANS FOR LUBRICATION  
Details of a Compression Shackle Supported by a Stud Projecting from the Chassis Frame Are Shown at the Left. The Drawing at the Right Shows Means for Lubricating the Outer Steering-Gear-Shaft Bearing and the Rear Ball-Stud of the Drag-Link

to flush-out the bearings, except in cases in which a single header-outlet is divided; then, the pressure will be divided in accordance with construction. The fit and, consequently, the resistance of the bearings supplied does not affect the volume delivered to each bearing, since the measuring chambers are not in communication with the bearings under direct pump-pressure and, during the delivery period, the measuring chambers are only in communication with the bearing and are cut-off from the pump and also from each other.

The large oil-passages in the pump, through the primary tubing connecting the pump with the headers, and through the headers, permit the successful handling and elimination of any dirt or foreign matter that can pass the screen provided in the pump assembly. If a particle of dirt is caught under the inlet end of the header valve, the oil in the measuring chamber will partly return to the main supply-tube instead of returning to the delivery tube, and the next operation of the pump plunger generally will wash this particle of dirt through the header and clear the valve-seat. Dirt caught under the outlet valve will only cause a slight increase in the volume delivered by that particular outlet, and it is generally carried through the header, at the next operation of the pump, by the flow of oil under high pressure.

Leakage of oil past the inlet end of the header valve will result in leakage at the bearing supplied if the outlet of the delivery tube is below the oil level in the reservoir. If the bearing outlet is above the reservoir oil-level, the oil in the delivery tube between the bearing and the header will drain back into the primary supply-tube system and failure of lubrication at the bearing will result, since at one operation of the pump the header generally will not deliver a volume of oil sufficient to fill the delivery tube between the header and the bearing and supply some oil to the bearing. Maintaining the reservoir above all outlets of the system will reduce this chance of failure to the annoyance caused by too much oil at the leaky outlet. Installations using the dash pump-unit have a double check against failure due to the above causes, since the seal at the outlet passage of the pump supplements the action of the header valve in preventing leakage of oil.

In lubricating a single bearing with a controlled volume of oil delivered at each lubrication, the addition of two or three drops of oil to the large oil-passages and spaces in the bearing will not develop very great pressure in the bearing. It is necessary to supply the bearing with a volume of oil that completely fills the oil-passages and space in the bearing before pressure will be built-up. A pressure of 1000 lb. per sq. in. applied through an oil-passage  $1/8$  in. in diameter provides a direct force or push of about 12 lb. to force any obstruction through the passage; hence, it is evident that the use of high

pressure does not result in any great force to clear anything out of the bearing.

The header control will maintain a pressure on the oil in the delivery tube until the volume of oil forced-up into the air-chamber has been delivered to the bearing. This feature is of advantage in supplying oil to tightly fitted bearings which oppose great resistance to the flow of the oil; it is also of advantage in connection with the operation of the system at low temperatures, as it maintains a continuous push on the oil to overcome the increased resistance encountered in forcing cold oil through the delivery tube. A definite time-interval is required to force a given volume of cold oil through the delivery tubes, permissible increases in the operating pressure do not shorten this time interval materially. The system of control will handle the heavier engine cylinder-oils

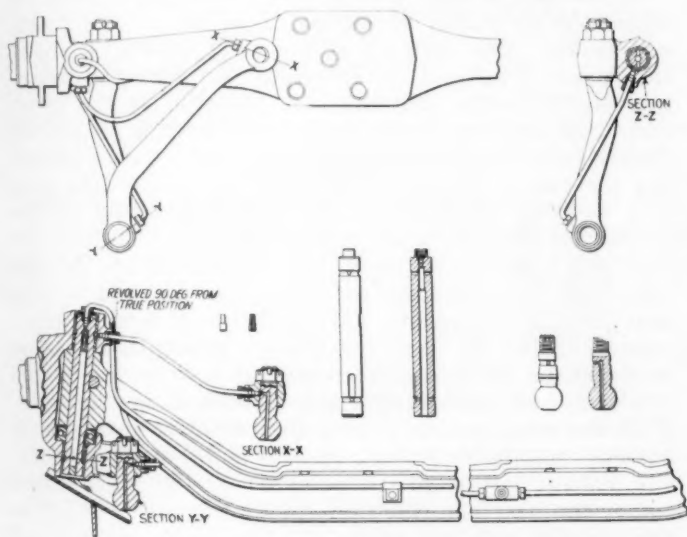


FIG. 9—DETAILS OF A FRONT-AXLE ASSEMBLY

In constructions of this character, the volume capacity of the oil-passages is so great that it is impracticable to deliver a volume of oil that will fill the oil-passages completely at each operation of the system; therefore, provision is made so that the delivery of a very small volume of oil at the top of the construction will assure a feed to all parts of the assembly.

successfully at a temperature of 20 deg. fahr. Below this temperature, the resistance developed by the pump plunger makes it advisable to use cylinder oil of low pour-test. Special assemblies of the system have been made which successfully handle lubricants similar to Mobiloil C or Duplex Liquid Grease; that is, transmission lubricants.

#### TUBING AND CONNECTIONS

The type of tubing connection used with the system can be manufactured cheaply, the connections are easily assembled and fittings are practically eliminated, as part of the connection is made in the unit to which lubricant is supplied. The tubing nut makes the connection by spinning the inner edge of the tapered sleeve against the shoulder in the connection. The fillet in the nut allows the tube to be bent at a sharp angle when leaving the connection. Any vibration originating either in the fitting or the tube is absorbed by the long bearing in the nut and is not transferred to the point in the tube weakened by the taper sleeve. The connection is made commercially by drilling with a special formed center-drill and tapping a  $\frac{3}{8}$ -in.-24 S.A.E. Standard thread.

Pure-copper tubing having a wall thickness of 0.05 in. is used in installations. A 5/16-in. tube is employed between the pump and headers for the primary system and 3/16-in. tubes are utilized between the headers and

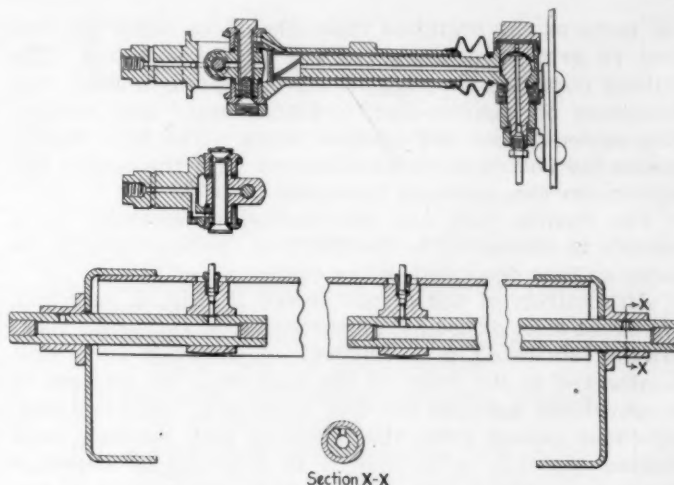


FIG. 10—BRAKE-MECHANISM LUBRICATION

Provision for lubricating a front-wheel-brake mechanism is shown in the upper view, and the constructions employed to lubricate both ends of cross-chassis brake-shafts are depicted in the lower drawing.

the points lubricated. In some installations, 3/16-in. tubing with a 0.035-in. or a 0.065-in. wall is required at one point. This tubing is produced with clean bores by a special process in which oxidation is prevented by excluding air during the annealing process. This heavy-wall tubing shows great ability to resist crystallization when subject to vibration and will withstand rough handling during assembly without closing the bore.

An additional control of the volume of oil delivered from a header outlet is secured by using a special tee fitting. A measured volume of oil is delivered at the tee, from which branched tubes extend to the bearings. By opposing equal-length tubes with equal bores, equal pressures will be developed and equal volumes of oil delivered at the respective outlets. By opposing tubes of unequal length and unequal bores, the tee can be placed near one of the outlets and equal volumes delivered at the outlets. Where this construction is used, the tee and

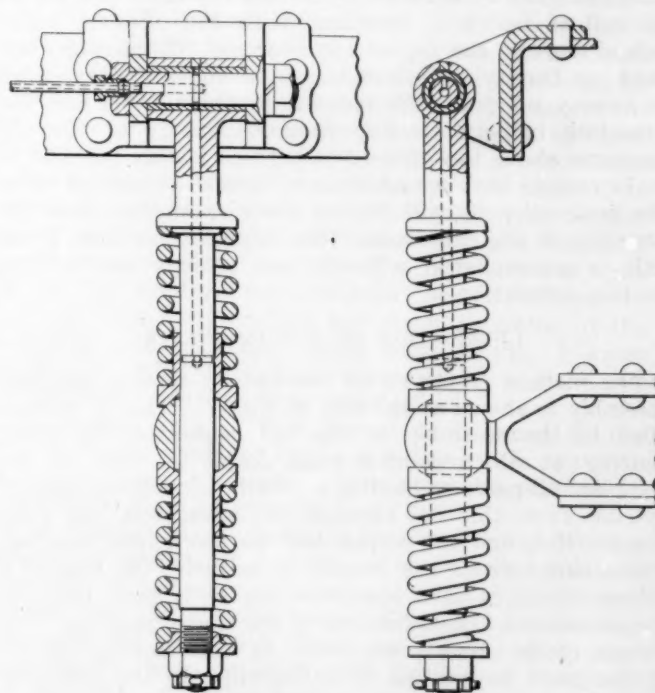


FIG. 11—TORQUE-ARM LUBRICATION

The drawing shows the means employed for lubricating the moving parts of the front end of a spring-cushioned torque-arm.

all parts of the branched tubes should be below the outlets to prevent drainage of the branched tubes. The tubing clips are supplied in various types to hold combinations of gasoline-line, hydraulic-brake and lubrication-system tubes and electric wires. The lock washer under the bolt head, in combination with the square nut held in the clip, prevents loosening.

The flexible tube and the method of assembly on a chassis to convey oil to the front or the rear axle is the same as that described in the earlier paper.<sup>3</sup>

An analysis of the layout shown in Fig. 5, in which the front axle, drag-link, all spring-bolts, and brake rockers are lubricated, is as follows: A reservoir pump-unit is attached to the front of the dash with the plunger in a convenient position for foot operation. Primary supply-tubes extend from the pump to four headers, each located centrally with respect to a group of bearings lubricated. Short tubes extend from the headers to the various chassis-points lubricated, including one flexible tube extending from the chassis frame to the front axle. The primary system is all located within and protected by the chassis frame and has only 12 tubing connections; any break or serious leak in this part of the system renders the complete system inoperative. Any break or leak in the connections between the headers and the points lubricated will affect only the part supplied and not the complete system. The parts are placed so that they are protected from damage and permit service work to be carried on without disturbing the tubing or connections.

Fig. 6 shows a sectional view of the assembly of a front axle and the means of supplying lubricant to the knuckles and the ball studs of the steering-rods. The delivery from a header outlet is carried through a flexible tube along the inside of the rear half of one of the front springs to a tee placed on the rear of the axle. From the tee, branched tubes extend to connections machined in bosses on the rear of the axle enlargements in which the steering knuckles operate; these branched tubes are opposed so that equal volumes of oil are delivered to each knuckle. The construction provides for each knuckle an oil-well in which it operates, with the oil-level maintained close to the top of the bearing. Oil-passages extend up through the knuckles, and tubes are extended to convey oil from the knuckle to the tie-rod and the drag-link ball-studs. The volume capacity of the oil-passages above the oil-level is held as low as possible to make certain that the addition of a small volume of oil to the main oil-wells will fill the tubes extending from the knuckles to the ball studs. The lubrication of the front axle is accomplished with the use of only one moving flexible connection.

#### LUBRICATION OF SPECIAL PARTS

The method employed to lubricate a tension shackle-assembly is shown at the left of Fig. 7. The oil is supplied to the assembly at the top center of the lower bearing, at which point a small flat is provided on the bolt; an oil-passage having a small volumetric-capacity extends from this flat through the lower bolt, the side-shackle link and the upper bolt to the upper bearing. The oil-feed from the header is adjusted to supply a volume of oil at each operation that will more than fill the passages in the assembly to the upper bearing. The weight of the chassis supported by the bearing contact at the point where the oil is supplied to the assembly assures a continuous oil-passage to the upper bearing

even after considerable wear has taken place. The drawing at the right of Fig. 7 shows the means employed to lubricate a compression shackle-assembly.

The same general arrangement is used for spring brackets and shackle assemblies of conventional design. The same bolt is used in all brackets and shackles, the bolt having an oversize grind of from 0.002 to 0.003 in. at the head end for an oil-tight fit in the bracket; a single flat is provided on the head, with the oil-passages in the bolt located in relation to this flat. All tubing connections are made to bosses incorporated in the brackets and located so that they are protected from damage. A shoulder on the bracket provides for the proper location of the oil-passages in the bolt when the flat on the bolt head is assembled in relation to the shoulder on the bracket.

At the left, in Fig. 8, details of a compression shackle supported by a stud projecting from the chassis frame are shown. The drawing at the right of Fig. 8 shows the means employed to lubricate the outer steering-gear-shaft bearing and the rear ball-stud of the drag-link. Oil supplied to the outer shaft-bearing is carried through communicating oil-passages and a tube connecting the end of the shaft with the ball stud. The general adoption of balloon tires and front-wheel brakes forced the steering-gear manufacturer to eliminate the play and noise in the gear and, to accomplish this result, most steering-gear cases are packed with a very heavy viscous lubricant. The addition of even a small volume of the oil used for chassis lubrication to this lubricant in the gearcase results in a thinning of the lubricant and subsequent noise developed in the gear. With the construction shown, the lubricant in the gear housing maintains a head on the outer shaft-bearing; any leakage is toward the point where the shaft comes out of the bearing. Oil supplied by the chassis-lubrication system will not work into the gear housing and thin the gear lubricant.

Fig. 9 shows the assembly of a front axle in detail. In constructions of this character the volume capacity of the oil-passages is so great that it is impracticable to deliver at each operation of the system a volume of oil that will fill the oil-passages completely; therefore, provision is made so that the delivery of a very small volume of oil at the top of the construction will assure a feed to all parts of the assembly. A stand pipe installed in the passage at the top of the king-bolt maintains an oil-level at that point, and the addition of any oil at the top of the king-bolt will force some oil out to the top bearing and through the tube extending to the front drag-link ball-stud; at the same time, some of the oil will pass through the stand pipe to the point Z-Z where another oil-level is maintained and where the oil passes out to lubricate the lower bearing and through the extended tube to the tie-rod ball-stud. The tubes move as part of the construction, and no motion or swivels are introduced. The construction provides sediment pockets for dirt that may work into the passages. A drip-pan is provided below the knuckle, and the bottom of the lower bearing is left open to allow the oil to work through and carry dirt out of the bearing. Constructions having the lower bearing closed at the bottom collect water which, in turn, floats the oil out of the bearing and causes failure. Tubing connections are machined in bosses on the parts supplied, and the ball studs are drilled to provide oil-passages when assembled in place.

<sup>3</sup> See THE JOURNAL, April, 1924, p. 424.

# Evaporative Cooling

By HERBERT C. HARRISON<sup>1</sup>

DETROIT SECTION PAPER

THE discussion following the presentation of this paper at the Detroit Section meeting that was held on Dec. 3, 1925, was constituted of remarks made from the floor. In accordance with the usual practice, the stenographic report of these remarks has been submitted to the various speakers for their approval and to the author for any additional comment that he cared to make. The corrected discussion, as received, is printed below. An abstract of the paper precedes the discussion so that those of the members who did not read the paper when it was printed in the February issue of THE JOURNAL can gather some knowledge of the subjects covered by reading the abstract if they do not wish to read the complete text.

## ABSTRACT

FIRST taking exception to the term "steam cooling" because of its association with steam heating, and suggesting "evaporative cooling" as more appropriate, the author describes the results of 7 years' experimentation with various modifications of an original system and declares that the latter has proved itself to be the most satisfactory.

The problem is stated to be merely that of cooling an internal-combustion engine with boiling water, using the water as a carrier of the steam produced to transfer the very considerable quantity of heat contained in the steam to a system suitable for condensing the steam and wasting its latent heat by condensation.

After detailing the many shortcomings of the conventional water-cooled system, which include the liability of the system to become stagnant because of the formation of steam-pockets and the consequent inoperativeness of the pump; the excessive size of the radiator required to meet the maximum demand while running with wide-open throttle, at maximum possible speed, in a hot climate, or at a great altitude; the unsuitability of such a radiator for normal operation during the greater part of the year; and the problem of crankcase-oil dilution due to overcooling, the advantages of evaporative cooling are outlined.

Although the problem of allowing water to boil in the cylinder jackets, the steam formed to be condensed and the condensate to be returned does not seem difficult, many practical considerations must be taken into account.

Experiments with numerous variations of the original system are described, such as operating at a variable or a fixed pressure; at subatmospheric, atmospheric or superatmospheric pressure; with the steam circulating downward as in ordinary radiator practice, from side to side or introduced at the bottom and allowed to flow upward; or with dry steam, wet steam or steam and water.

Of these variations the most satisfactory combination is said to be that in which wet steam containing water is introduced into one side of the radiator-core, the water being allowed to traverse the lower tubes and the steam the upper tubes of the radiator. The steam in crossing the radiator is condensed and trickles down

to the water and both are returned by one pump to the cylinder-block.

The general principles said to apply to successful operation include:

- (1) Rapid circulation of water through the jackets into the cooling-system
- (2) Maximum temperature-difference between the air and the core
- (3) A centrifugal pump operating with slightly cooled water, a gear-pump being undesirable
- (4) Prevention of an air-lock in the condenser, and the venting of the cold side of the condenser to the atmosphere
- (5) Provision for the care of residual heat in the cylinder-block to minimize the loss of steam after hard driving and sudden stopping
- (6) No loss of water or alcohol under any circumstances
- (7) No retardation of rate of circulation of steam
- (8) Air-flow and rise of temperature of the air dependent on the volume of air passed and the turbulence within the radiator
- (9) Interchangeability of the condenser with a standard radiator
- (10) Capacity, when fully filled with water, of operating as a superior water-cooled system

## THE DISCUSSION

T. J. LITTLE, JR.:—I believe that steam-cooling is fundamentally right, and that we shall come to it eventually. Some of us may have a hard time in being convinced, but I think we shall all be convinced in the end.

F. E. WATTS:—From the work that we have done in the last 2 years on evaporative cooling, I see no reason why it will not work, from the practical point of view, as we have it now. One question that has arisen, which we have not had enough experience yet to answer, is whether it will be possible to use as high compression and get as great volumetric efficiency with steam-cooling as with water-cooling. Perhaps Mr. Harrison has some data on the mixture temperatures used. Perhaps we might combine steam-cooling and steam-jacketing of the intake-manifold to obtain quick warming-up. I know that this has been worked out theoretically, at least, but I do not know whether it is practical.

Due to the kinds of fuel that it is necessary to use these days, it is evident that some changes in the cooling-system must be made. Cars must be warmed-up more quickly than at present.

In a number of evaporation tests made on ordinary commercial grades of gasoline sold by nine different companies in Detroit, none being the so-called high-test gasoline, the initial-point ranged from 106 to 126 deg. fahr. and the end-point, from 433 to 468 deg. fahr. These results were obtained with Bureau of Standards test methods. Gasoline having an initial-point of 106 deg. fahr. and an end-point of 468 deg. fahr. will need more heat than it has been given in the past.

<sup>1</sup> M.S.A.E.—President and general manager, Harrison Radiator Corporation, Lockport, N. Y.

<sup>2</sup> M.S.A.E.—Formerly chief engineer, Lincoln division, Ford Motor Co., Dearborn, Mich.

<sup>3</sup> M.S.A.E.—Chief engineer, Hupp Motor Car Co., Detroit.

HERBERT HARRISON:—Mr. Watts is right. The higher the temperature of any part of the cylinder-block and valves, the more the mixture will tend toward detonation trouble; but if an engine is over-cooled so that it is free from "pinging" trouble, it will not be sufficiently warm in winter. If an engine is designed so that, as a water-cooled job, the trouble is taken care of in summer, it will not give trouble in winter, as a condensing job. The power does not fall off when the spark is retarded with a condensing radiator in the same way that it does in the water-cooled system.

A MEMBER:—One of the best points Mr. Harrison has brought out is the fact that, so far as what takes place in the cylinder-jacket is concerned, the action of steam-cooling is practically identical with that of water-cooling. The action is very much the same as that which takes place in a water cooling-system that is forced.

In connection with the supposedly more effective radiator-capacity, that is, that less radiator-capacity can be used with steam-cooling, sometimes we find in experimental work that we get certain results; if we try to check back we find that we do not get the same results. We do not find that so much by the figures, perhaps, as we do by actual experience. When such a case occurs, we must look for some reason for it. Some fabulous claims have been made in various quarters as to the small amount of radiator-capacity that can be used with steam-cooling; and it has been said that we do not know why, but it has been found by experiment to be true.

MR. HARRISON:—If dry steam is used, a weight of radiator-core about 66 per cent of that used in a water-cooled car will be sufficient. If really wet steam is used, there is still an advantage, which is nearly 33 1/3 per cent. That is natural, because the efficiency of the radiator depends upon the mean difference between the temperature of the air and the temperature of the water. Another point that tends toward efficiency with steam-cooling is apparent when the volume of steam is compared with that of water. When steam is condensed, the contraction in volume is enormous, being approximately 2600 to 1. That naturally sets up excessive turbulence inside the radiator-core. In a water-cooled system, a film of water that is more or less dead is near the tube.

QUESTION:—How about the application of steam-cooling to aircraft in which reduction of the core-area is of paramount importance from the points of view both of weight and of parasitic resistance?

MR. HARRISON:—The core-area could surely be reduced for the reason just stated. I am not sure that the same reduction would be possible in aircraft work as in an automobile, for the speeds of the air and the water through the radiator are much higher. As I recall, water is circulated at the rate of about 100 gal. per min. It is many times faster than through a water-cooled system. The greatest possible reduction in core is obtained when a thermosiphon system is replaced with a condensing-system.

QUESTION:—One advantage not mentioned is that the engine will reach its working-temperature more quickly after starting, owing to the smaller quantity of water to be heated. This is of special advantage when a car is used for short runs in cold weather.

MR. HARRISON:—Take the case of a doctor. After he has driven for about 2 miles, the system will reach a boiling-temperature; it will not cool off in zero weather for 20 min. or 1 hr. The steam cooling-system heats-up in about one-third the time and stays warm

about six times as long as an ordinary system, which is a great advantage.

QUESTION:—Have you observed any superheating, or water thrown into a spheroidal state, as is possible and common in laboratory tests?

MR. HARRISON:—I have no doubt that this might happen on the inside of a jacket where there is a hot-spot; but the usual limitations are the same for condensing radiators as for a water cooling-system. The faster the water circulates, the less will be the chance of getting it into the spheroidal state from any of these hot-spots. Even if the water does not circulate, the turbulence would be so violent that it is unlikely that trouble will occur. As a matter of fact, the spheroidal state causes no trouble.

QUESTION:—How much weight could be saved over that of the present-day system, in adapting the steam cooling-system to a car of the size of the Chevrolet?

MR. HARRISON:—The maximum saving would be about 33 per cent. A Chevrolet radiator-core weighs about 12 lb.; possibly 3 lb. would be saved. In some high-capacity radiators, the saving might be 10 or 12 lb., depending entirely on the car under consideration.

QUESTION:—Where less spark-advance was required for steam-cooling than for water-cooling, were the combustion-chamber shapes and the spark-plug positions identical in the two tests?

MR. HARRISON:—Yes; they were identical in the tests I mentioned. But before the tests were made, considerable work had been done in endeavoring to get the best spark-plug position to suit high-temperature water operation. The tests showed conclusively that spark-advance was not so important as in the ordinary water cooling-system.

QUESTION:—What difficulties were found in using an injector for returning water to the cylinder-block?

MR. HARRISON:—That is a long story. The difficulty was very great. Anyone who tries to inject any boiling liquid from one place into another, will find it so. If you succeed, it will work fine. We secured a system that could be operated but quickly abandoned it in favor of a centrifugal pump.

QUESTION:—In the cross-flow system, what is the relation between the normal water-level in the radiator-core and that in the cylinder-head? Are the heights the same?

MR. HARRISON:—In the best example of the cross-flow radiator, the level of the water in the radiator would be a little more than one-third the full height. Of course, the relation that that level bears to the level in the cylinder-head depends on the position in which the radiator is placed on the car; the best results are obtained when the radiator is a little more than one-third full.

QUESTION:—With the so-called dry-steam system, do you find the rate of heat-transfer per square foot per degree of temperature-difference to be less than that with the wet-steam system?

MR. HARRISON:—I have no doubt that the rate of heat-transfer is better with the dry-steam system; but that is only half the problem. The other is to get heat into the fluid around the cylinder-block, which is much more important than getting rid of it at the other end. The heat would be wasted most effectively when dry steam is condensed.

QUESTION:—Will not the cooling-effect on the top of the combustion-space in an L-head engine due to the greater scraping-action of steam bubbles along the sides of the cylinder be less than from the top?

MR. HARRISON:—No doubt a condensing system is

easier to design and handle with an overhead-valve than with an L-head-valve engine but, on the other hand, if the steam-chest were made as in the cross-flow system and the liquid in the cylinder-block were intentionally kept under pressure, more or less solid water at a temperature about the normal boiling-point and at about the normal boiling-pressure would shoot over into the side tank of the radiator. The pressure will then drop to normal atmospheric, and the temperature will drop to 212 deg. fahr.

QUESTION:—How does the alcohol get back into the water in the cylinder-jacket, when the engine is stopped after a hard run?

MR. HARRISON:—If the alcohol is not condensed, it does not get back; if it is condensed, the pump forces it back.

QUESTION:—Assuming that no device is absolutely perfect, will you state what are the disadvantages of the steam cooling-system?

MR. HARRISON:—The only thing that I can conceive to be important is the fact that, when a car is stopped after a hard run, reserve heat remains in the cylinder-block. The cooling-water has risen to the boiling-point and the excess heat must go somewhere. It will boil the water and make steam. The reserve heat in the cylinder-block must be taken care of. The suggestion I made of having this reserve water in the top and a subsidiary small radiator meets the case. The quantity of heat is very small, practically. Idling the car for ½ min. with the fan going will be sufficient. We have not had much trouble. A car of that kind can be driven up Uniontown Hill and the ignition be shut off at the top without getting an extra "putt" out of the engine. Any other system would surely lose some steam.

QUESTION:—Is there not a gain owing to the smaller quantity of water handled and, therefore, less power absorbed by the pump? Have you data?

MR. HARRISON:—I am more interested in cooling the cylinder-block than in the infinitesimal amount of power required to circulate either 15 gal. per min. horizontally, or even 1 gal. I should prefer to keep the car cool rather than to worry about the quantity of water pumped. It is not pumped uphill, only raised about 6 in. at the outside.

QUESTION:—What is Mr. Harrison's opinion regarding placing the condenser at such a level that a gravity-feed of water back to the bottom of the cylinder-block will take place; in other words, to place the top level of the water in the condenser on a level with the top level of the water in the cylinder-jacket?

MR. HARRISON:—The idea is excellent, but I do not know how you will sell it to the public. Such a condenser would not look well on the car. If placed horizontally it would look all right, but air must circulate through it. It is not easy to have the radiator above the engine and get the air through it. To circulate air, the air must be pushed up. I do not think it will be practical for 2 or 3 years yet. When the system is in general use, all the disadvantages will be found and corrected.

QUESTION:—What is the best kind of pump for a steam-cooled system? Is it desirable to increase or decrease the thickness of the jacket space around the cylinders?

MR. HARRISON:—Without question the more free jacket space that is provided, the better it will be, and the less will be the possibility of forming steam-pockets. As to the best kind of pump, I should say the pump that throws the most water is the best. Anything that is good for a water cooling-system is good for a steam cooling-system.

QUESTION:—Is it necessary to change the speed of the fan under average conditions?

MR. HARRISON:—Under average conditions, the fan could be taken off and discarded; but under other than average conditions it is sometimes advantageous to have the fan attached. When running in low gear, or standing at the curb, air must circulate through the radiator; if it does not circulate by running, it will be necessary to use a fan.

QUESTION:—What is the disadvantage of a positive-acting pump as compared with a centrifugal pump?

MR. HARRISON:—Nothing is the matter with a positive-acting pump, if it will stand up. In the first car I owned, which was bought second-hand and had a four-cylinder engine, I put in three pumps before I had finished with my tests; and they all wore out. I prefer to rely on a centrifugal pump of good design.

## CHASSIS LUBRICATION

(Concluded from p. 496)

The upper drawing of Fig. 10 shows provision for lubricating a front-wheel-brake mechanism extending from the frame to the front axle. The pumping action of the sliding shaft in the bearing results in very efficient lubrication of the universal-joint and the rocker-shaft in its bearing. The lower drawing shows constructions employed to lubricate both ends of cross-chassis brake-shafts; the oil supplied to one bearing lubricates that bearing and also feeds into the hollow shaft, which has an outlet at the top of the shaft in the other bearing. Fig. 11 shows the means employed for

lubricating the moving parts of the front end of a spring-cushioned torque-arm.

This system has been in production for the last 2 years with between 60,000 and 70,000 cars in the field. Satisfactory results have been obtained with systematic operation. No trouble has been experienced from breakage of tubing or flexible connections. Field results show that the best lubrication is attained by use of the heavier grades of engine cylinder-oils which have great viscosity. These grades of lubricant stay in place in the bearing and prevent the entrance of either water or dirt.



# New York City's Motor-Vehicle Traffic Problem

THE question of communication in New York City and its environs had reached such proportions that a study was made of the existing conditions with the object of dealing with over-crowded traffic on highways as part of the problem of communication facilities. This project was undertaken by the Regional Plan of New York City and its Environs. The data collected thus far have been published in report form and deal with traffic only. A subsequent report will take up transit and transportation. The present report entitled *Highway Traffic in New York City and Its Environs*, which is monograph No. 1 of the engineering series of the Regional Plan, is by Harold M. Lewis in collaboration with E. P. Goodrich. Mr. Lewis discussed various phases of this report at the October, 1925, meeting of the Metropolitan Section of the Society.

In making this traffic study the committee concentrated its efforts on an endeavor to

- (1) Summarize the nature of the problem
- (2) Locate the points of greatest congestion, to ascertain the plans already in process of execution or under consideration by the public authorities which are designed to relieve such congestion and to weigh the relative merits of such plans where there are alternates
- (3) Suggest plans for relief where none has yet been proposed
- (4) Point out places where congestion will soon be serious, unless steps are taken in advance to avoid it and to indicate what preventive treatment can most economically and effectively be applied

This report on the Highway-Traffic Problem in New York City and Its Environs incorporates an investigation of the present highway facilities in the area, the main factors which have influenced the rapid growth in the development of motor-vehicle use within different parts of the area and the probable future of such trends, the various methods of relieving traffic congestion and the ability of existing and proposed facilities to take care of future traffic demands, as well as a presentation of the basic data needed for the satisfactory solution of both the regional and local highway problems and highway proposals for various sources.

A number of outstanding facts and figures have been revealed by this investigation and because of their significance some of these are enumerated herewith.

## SIGNIFICANT STATISTICS

The one-way vehicular traffic entering Manhattan, south of 59th Street during 24 hr. on a typical 1924 business-day, is estimated at 204,750 vehicles; of this total 64.9 per cent comes from the north, 27.1 per cent from Long Island, 7.4 per cent from New Jersey, by ferries south of 59th Street, and 0.6 per cent from Staten Island. It is estimated that there were, under normal 1924 conditions, approximately 58,700 vehicles upon the streets of Manhattan at one time and that about 23,500 of these were moving vehicles.

In connection with trolley-cars and motorcoaches, it has been noted that the number of passengers handled by surface car-lines in the Metropolitan region has remained practically stationary since 1914; that the number of passengers carried by the Fifth Avenue Coach Co. has increased about five-fold since 1914; that the number carried by motorcoaches operating out of Newark has increased about twelve-fold since 1917; and that about 3.1 passenger automobiles can be accommodated in the space within a street occupied by a trolley-car and 1.4 passenger automobiles in the space within a street occupied by a motorcoach.

That there is a periodical variation of traffic is shown by the following examples. Truck traffic on Fourth Avenue, Manhattan, is very uniform from Mondays to Saturdays inclusive. The streets adjacent to the central congested area show the heaviest truck-traffic on Fridays. Manhattan cross-town-traffic is principally motor-truck traffic, which is about twice the passenger-car traffic, and three times the taxicab and motorcoach traffic.

On arterial highways the maximum traffic occurs during August and varies from 135 to 225 per cent of the average weekly number. The seasonal variation of traffic throughout a year is much greater on the highways in the outlying parts of the region than on those in the central area.

## STREET CAPACITY

Street capacity obviously has a great effect on traffic congestion. It has been noted, for instance, that the capacity of a street expressed in car-miles continues to increase with the velocity, while the number of vehicles that can pass a certain point per hour decreases after the velocity exceeds 14 or 15 m.p.h. One thousand eight hundred and eighty vehicles per hour is the maximum that might be expected on a single lane of uninterrupted traffic and could be obtained with velocities of about 15 m.p.h. One thousand and twenty vehicles per lane per hour is the maximum that might be expected on a single lane of traffic on a street with tower traffic-regulation, and could be obtained with running velocities of about 14 m.p.h. In a street with several moving lanes, the average lane-capacity will probably not exceed 80 per cent of the maximum single-lane capacity.

## AVERAGE LENGTHS OF HAUL

The length of haul is an interesting factor, as will be seen from the data given below. The average length of haul of Manhattan taxicabs is about 1.50 miles. The average length of haul of trucks handling railroad freight in Manhattan was 1.36 miles in 1918 and has increased about 34 per cent since 1913.

The average length of haul of all motor vehicles passing a fixed point was found to be 55.2 miles on a typical Sunday, and 56.0 miles on a typical weekday. About 45 per cent of all traffic originating within a district on a typical day travels at least 30 miles.

## REGULATIONS AND PLANNING

Some suggestions were made relative to traffic regulations and planning, and are as given herewith.

While regulation of traffic has been carried about as far as is desirable in the central congested area, there is still opportunity for considerable improvement in the regulations in the outlying districts.

A platoon system of traffic control would greatly increase the average speed of vehicles and result in an increase of car-mile capacity of about 100 per cent.

Restricting the time at which certain trucking operations can be carried out would relieve congestion in the business areas.

Additional parking facilities accessible to the business district must be provided. Serious blocking of streets and sidewalks by the unloading and storage of merchandise is unjustifiable.

Physical planning can accomplish better results than regulation in bringing about the segregation of through and local traffic.

Highways must eventually be provided for the special use of motor trucks.

(Concluded on p. 513)

# Gasoline Volatility

By W. S. JAMES<sup>1</sup>

ANNUAL MEETING PAPER

Illustrated with DRAWINGS AND CHARTS

## ABSTRACT

**M**EASUREMENT of the volatility of motor fuels by batch distillation is regarded by the author as unsatisfactory because the carbureted fuel is vaporized in an internal-combustion engine by continuous distillation, hence there is great difficulty in correlating the temperatures of test with those of actual use. Whereas formerly gasoline was produced by batch distillation in the refinery, it is produced now by removing the gasoline from crude oil by continuous distillation or is produced by cracking and continuous fractionation. Therefore the temperatures of production also bear no rational relation to those of test by batch distillation. Similarly, in an engine, fresh gasoline is supplied continuously by the carbureter and is vaporized continuously in the manifold and cylinder, all of the constituents being present at any time in any cross-section of the manifold.

To determine whether or not volatility can be measured by a continuous-distillation method, the temperatures of such test translated readily into those of production and use and the practicability of such tests for routine use, simple laboratory test-apparatus was constructed and test runs were made with various fuels. The apparatus is illustrated and described.

Results of the tests show two marked differences from results of batch distillation. The temperature range of distillation is much smaller and the percentage of bottoms, or unvaporized fuel, shows approximately a linear relation with temperature. With the gasolines tested, practically nothing was vaporized below 160 deg. fahr. and all of the gasolines were vaporized completely below 320 deg. fahr. It is held that if this laboratory method is truly representative of the process of distillation in an engine, it should be possible to translate the temperatures of test into those of use if an estimate can be made of (a) the reduction of hydrocarbon-vapor pressure due to the presence of air, and (b) the effect of pressure on the temperatures of vaporization. A simple method of estimating actual partial pressures of hydrocarbon vapor in an air-gasoline mixture from the molecular weight of the gasoline, the ratio of weights of air and gasoline in the mixture and the total pressure of the mixture in the manifold is given.

Tests made with the apparatus when fitted with a bubble tower apparently confirms the surmise that the overhead temperature of a fractionated vapor-stream will correspond closely with the temperature of zero bottoms when the tower stream is free from steam and liquid entrainment and that the effect of steam can be corrected with reasonable accuracy. A test made with a blend of equal volumes of benzol, zylol and toluol indicates that fractionation in the apparatus is practically negligible, which may account for the linear relations found with gasolines. Estimation of the volatility of blends is comparatively easy by mathematical computation from continuous-distillation curves of the blended materials.

The author believes that simple laboratory continuous-distillation methods should receive serious consideration and that the proposed test method should give rise to the development of a definition of gasoline vola-

tility that will be more acceptable to producer and user than methods now in use.

**W**HILE the importance of suitable volatility of motor fuels needs no comment, I believe, the general method now used to measure volatility is unsatisfactory. These fuels are vaporized in an engine by a continuous process of distillation but their vaporization characteristics are measured by batch distillation. Is it surprising, therefore, that extreme difficulty is encountered in correlating the temperatures of test with those of actual use?

Carbureted fuels burned in internal-combustion engines have been, and always will be, vaporized in the manifold and cylinder by what is commonly termed "continuous distillation". Fresh gasoline is supplied to the engine continuously by the carbureter and, as it passes through the manifold to the combustion-chamber, is vaporized continuously. The lighter portions are vaporized first, then the heavier and next heavier portions until, if the proper temperatures are reached, all of the fuel becomes a vapor. During this vaporization process, all of the constituents of the fuel are present at any cross-section of the manifold, the proportion of the fuel that remains in the liquid state being controlled by the temperature of the liquid particles.

An entirely different method, commonly termed "batch distillation", is employed for measuring the volatility of motor fuels that are vaporized in the way described. A certain volume of the fuel is placed in a distillation flask and its temperature is raised slowly. As vapors are formed, they pass from the flask and are condensed. This process is continued until all of the liquid is vaporized. When the heavier portions are being vaporized, the vapor from the lighter portions has been removed from contact with the unvaporized liquid. Such a condition rarely, if ever, exists in an engine.

Petroleum products were produced by batch distillation until recent years but today very few are produced by this method, and gasoline never; the process is too slow and expensive. Gasoline is removed from crude oil by continuous distillation or is produced by cracking and continuous fractionation. Consequently, the temperatures of production bear no rational relation to those of test by batch distillation. Some obvious questions arise from these facts such as (a) Why cannot the volatility of a motor fuel be measured by a continuous method of distillation? (b) Can the temperatures of test obtained by continuous distillation be translated readily into those of production and use? (c) Are the difficulties encountered in a continuous distillation in the laboratory so great as to make such a test impractical for routine use?

## SIMPLE CONTINUOUS-DISTILLATION TEST-APPARATUS

In an endeavor to obtain answers to these questions, the simple apparatus shown in Fig. 1 was constructed. It consists of about 18 in. of ½-in. pipe welded into a piece of 3-in. pipe that serves as a steam, or heating, jacket. One end of the ½-in. pipe, or flow tube, is

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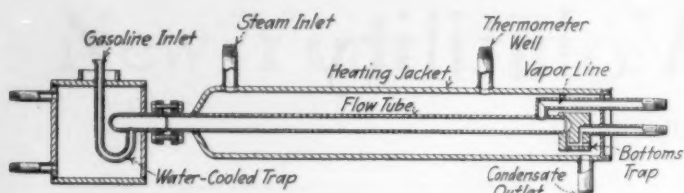


FIG. 1—CONTINUOUS-DISTILLATION TEST-APPARATUS

This First Apparatus Is Made of Standard Pipe and Is Mounted at a Slight Incline So That the Gasoline Flows Slowly from Left to Right and Is Heated by a Steam Bath. Vapors Pass Off through the Vapor Line to a Condenser and the Unvaporized Bottoms Are Collected in the Bottoms-Trap and Cooled. Premature Vaporization of the Gasoline Is Prevented by the Water-Cooled Trap at the Left

brought directly through the swaged-down end of the 3-in. pipe and its other end is fitted with a drilled block to serve as a liquid-trap. A vapor line is tapped into the 1/2-in. flow tube just ahead of the liquid-trap. The trap and the entrance to the vapor line are enclosed within the steam-jacket to maintain them at the same temperature as the flow tube.

Gasoline is fed to the flow tube from a burette, mounted above the water-cooled trap at the left, at a rate of from 2 to 5 cc. per min. The whole apparatus is mounted at a slight incline and the gasoline leaving the trap passes slowly down the flow tube. Before it reaches the liquid-trap at the right end, it is raised to the temperature of the heating bath and equilibrium is established between the composition of the liquid gasoline and that of its vapor. The vapor then passes through the vapor line to a condenser and the liquid flows through the bottoms trap to a liquid-cooler. After sufficient gasoline has flowed through the apparatus to establish a steady regime, a measured volume is flowed through the apparatus and the volumes of condensed vapor and unvaporized liquid are measured. To eliminate complications arising from condensation difficulties, the results of tests with the apparatus, as given herein, were obtained by measuring the volumes of bottoms, or unvaporized liquid, that resulted from flowing either 100 or 50 cc. of gasoline through the apparatus.

It was hardly to be expected that the temperatures desired would fall within the range of 212 to 350 deg. fahr. which could be obtained readily with saturated

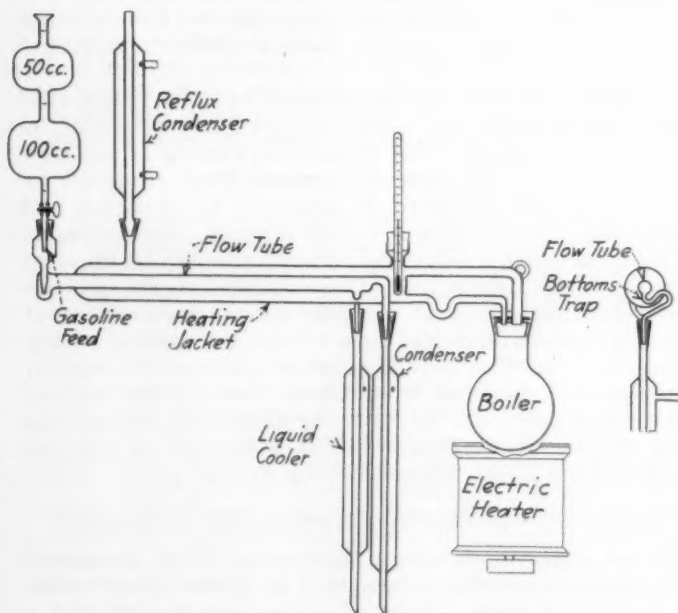


FIG. 2—TEST APPARATUS MADE OF GLASS

This Affords Visualization of the Distillation Process and Action of the Traps. The Flow Tube Is Heated by Vapor from a Boiling Liquid, Such as Water, Benzol or Amyl-Acetate

steam at available pressures, hence a second apparatus was constructed in which the flow tube was heated by an oil bath that could be held at temperatures ranging from 100 to 600 deg. fahr.

To obtain a clearer visualization of the process of distillation and of the action of the traps, the small glass apparatus shown in Fig. 2 was constructed. The flow tube of this apparatus was heated by vapor from a boiling liquid, such as water, benzol and amyl-acetate.

#### RESULTS MARKEDLY DIFFERENT FROM BATCH DISTILLATION

Results of the continuous distillation of four gasolines purchased in the open market are shown in Fig. 3, in

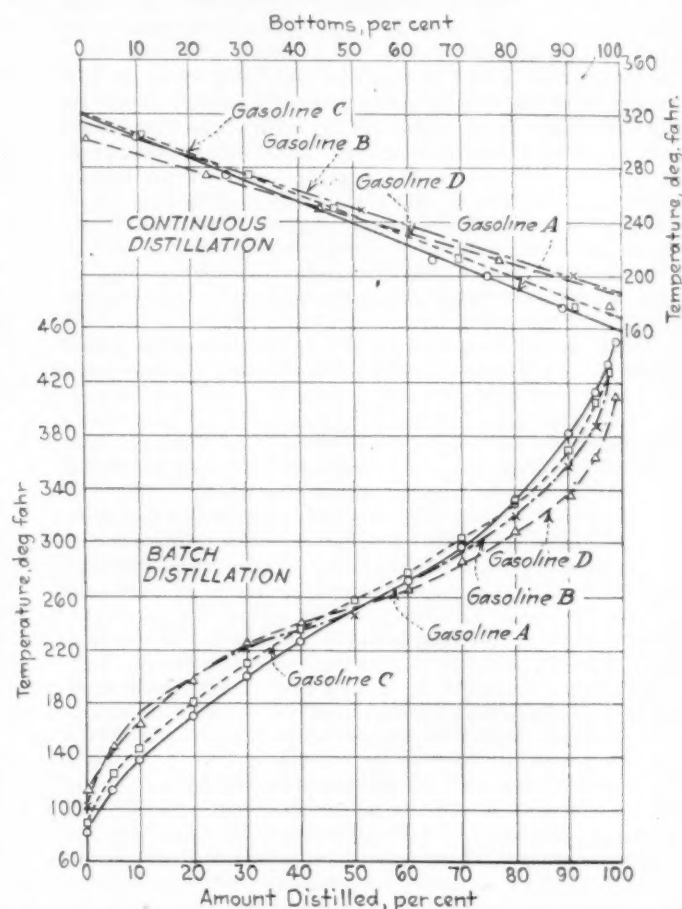


FIG. 3—RESULTS FROM CONTINUOUS AND BATCH DISTILLATIONS OF FOUR GASOLINES

Two Marked Differences Shown between Results Obtained from the Two Processes Are That, with Continuous Distillation, the Temperature Range Is Very Much Smaller and the Percentage of Bottoms Shows Approximately Linear Relation with Temperature. Practically Nothing Is Vaporized Below 160 Deg. Fahr. and All the Gasolines Are Vaporized Completely at 320 Deg. Fahr.

which the usual batch distillations for these gasolines are also given for comparison. The continuous-distillation tests show two marked differences from the results of the usual batch method. The temperature range is very much smaller and the percentage of bottoms shows approximately a linear relation with temperature. Practically nothing is vaporized below 160 deg. fahr., and all the gasolines are vaporized completely at 320 deg. fahr.

Results of the continuous distillation of a sample of domestic gasoline, a sample of absorption gasoline and a sample of a 50-per cent blend of both are shown in Fig. 4. The same characteristics appear as in the distillation of the finished gasolines.

Three of the difficulties encountered with the test apparatus are illustrated in this chart. It will be noted

## GASOLINE VOLATILITY

503

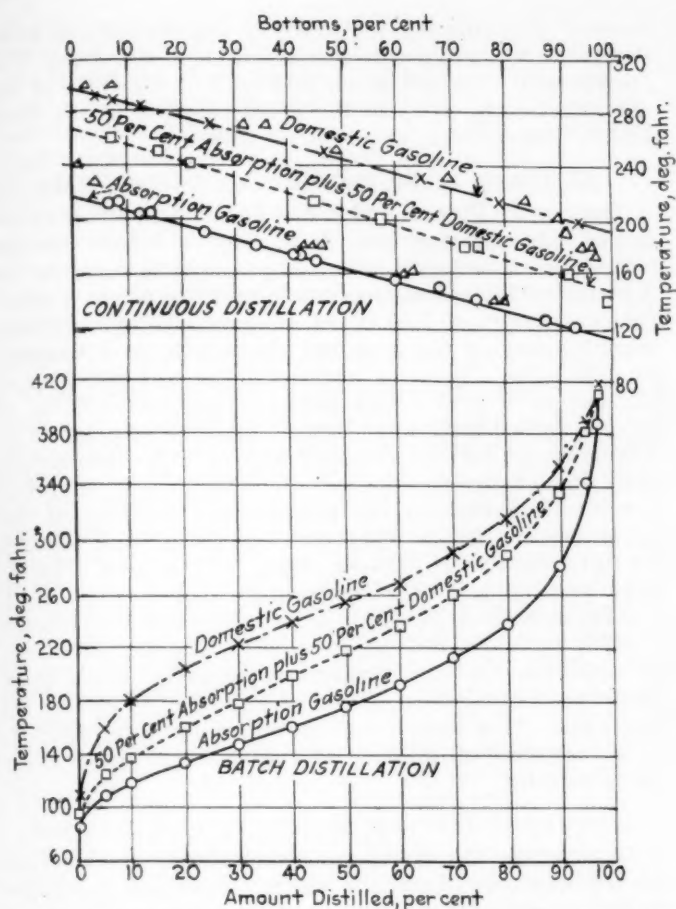


FIG. 4—RESULTS OF DISTILLATION OF SAMPLES OF DOMESTIC AND ABSORPTION GASOLINES AND A 50-PER CENT BLEND  
Points Enclosed in Triangles Were Not Used in Drawing the Curves as It Was Found That the Percentage of Bottoms Increased When Gasoline Flowed through the Flow Tube Too Fast and That It Dropped Too Much as the Percentage Approached 100, Due Probably to Air in the Tube

that the points marked with triangles are not used in drawing the curves. It was found that when the gasoline was flowed through the apparatus too rapidly the percentage of bottoms was increased, as the gasoline was not raised to the bath temperature, therefore the flow-rate was reduced until the minimum value of bottoms was obtained. It was also found that when the percentage of bottoms approached 100 per cent the curve seemed to droop more than would be expected from the other points. As the volume of vapor leaving the apparatus under these conditions was markedly less than the volume at the higher temperatures, it was believed that the presence of air in the flow tube reduced the partial pressure of the gasoline, therefore the end of the vapor-condenser tube was trapped, and then the percentage of bottoms fell more nearly on a straight line through the remaining points. When the test temperature was above that apparently necessary for complete evaporation of the gasoline, there was no liquid in the trap at the end of the flow tube and therefore the vapors condensed partly in the bottoms cooler as well as in the vapor condenser. The needed remedies for these three difficulties are obvious and are easy to find.

## TRANSLATION OF TEMPERATURES OF TEST TO THOSE OF USE

If the laboratory continuous distillation of motor fuels is truly representative of the process of distillation in an engine, it should be possible to translate the temperatures of test into those of use if an estimate can be made of (a) the reduction of hydrocarbon-vapor pressure due to the presence of air and (b) the effect of pressure on the

temperatures of vaporization. Estimation of the actual partial-pressures of the hydrocarbon vapor in an air-gasoline mixture is simple if the following factors are known:

- (1) Molecular weight of the gasoline
- (2) Ratio of weights of air and fuel in the mixture
- (3) Total pressure of the mixture in the manifold

As the results of a continuous-distillation test show an approximately linear relation between temperature and percentage of bottoms, it seems fair to assume that the temperature of 50-per cent bottoms is the average boiling-point. The average molecular weight can then be estimated from the boiling-points of pure hydrocarbons. The molecular weights of a number of the more common hydrocarbons plotted against their boiling-points are given in Fig. 5. These curves show the close similarity of the paraffins, olefins and cyclonaphthenes which probably represent the major proportion of the constituents of present gasoline.

A method for graphical computation of the actual hydrocarbon partial-pressures for a number of mixture-ratios and manifold pressures is given in Fig. 6, in which the values given are based upon the relation of molecular weight to boiling-point of the olefins between temperatures of 150 and 300 deg. fahr. The pressure scale at the left and the set of horizontal lines give the partial-pressure of the hydrocarbon vapor for any mixture-ratio between 10 and 20 to 1 and any average boiling-point from 150 to 300 deg. fahr. The pressure scale at the top of Fig. 6 and the vertically inclined lines reduce the partial pressure of the hydrocarbon vapor from that of a

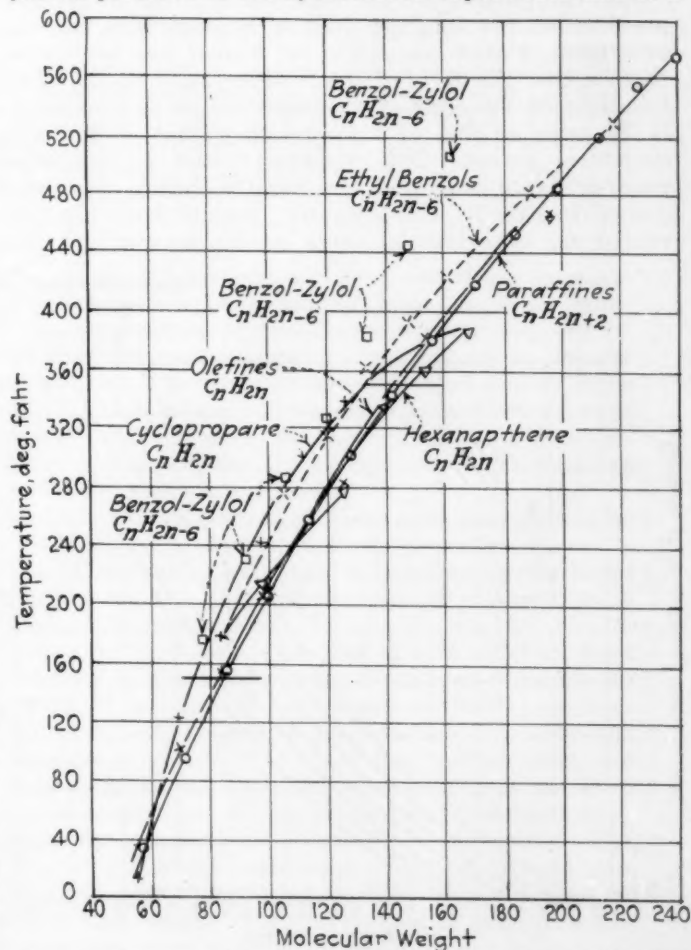


FIG. 5—MOLECULAR WEIGHTS OF CONSTITUENTS PLOTTED AGAINST BOILING-POINTS  
The Curves Show the Close Similarity of the Paraffins, Olefins and Cyclonaphthenes, Which Represent the Major Proportion of the Constituents of Present Gasoline

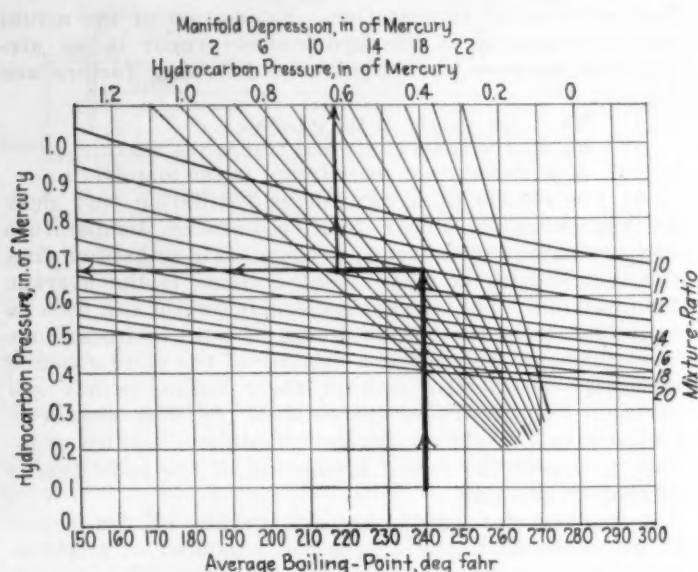


FIG. 6—HYDROCARBON PARTIAL-PRESSURES AT DIFFERENT MIXTURE-RATIOS AND MANIFOLD PRESSURES

Values Given Are Based upon Relation of Molecular Weight to Boiling-Point of the Olefines at Temperatures from 150 to 300 Deg. Fahr. The Scale at the Left and the Horizontally Inclined Lines Give the Partial Pressure of the Vapor. The Scale at the Top and the Vertically Inclined Lines Reduce the Partial Pressure from a Total Pressure of 29.92 In. of Mercury to That of Manifold Pressure at Depressions from Zero to 22.00 In. of Mercury

total pressure of 29.92 in. of mercury to that of manifold depressions from 0 to 22 in. of mercury.

For the purpose of estimating the effect of reduced pressure on the boiling-points of hydrocarbons, the approximate relation suggested by Walker has been used, that is, that the ratio of the boiling-points on the absolute-temperature scale of one compound at two pressures is the same as that of a second compound of the same structural series. This relation, based on published vapor-pressure data for the paraffin series, has been plotted in Fig. 7. Unfortunately, lack of time has prevented any experimental check on the accuracy of this

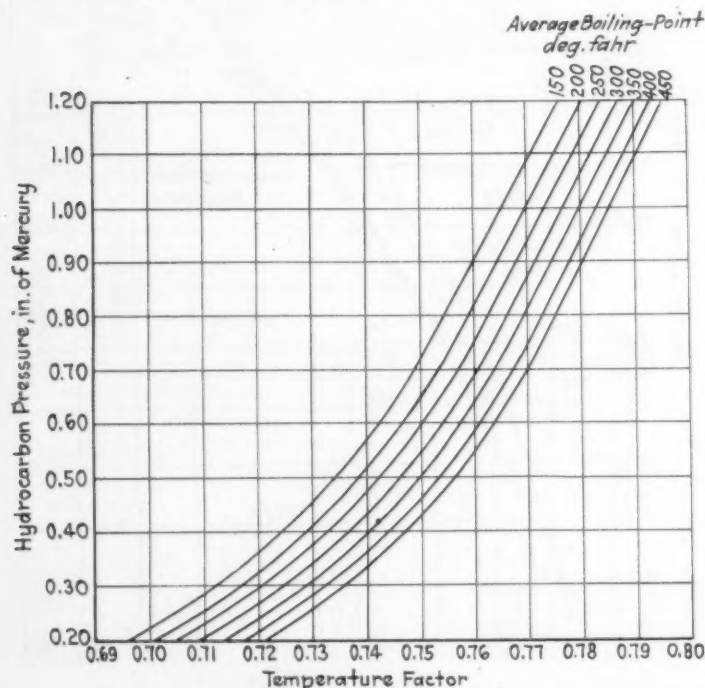


FIG. 7—EFFECT OF REDUCED PRESSURE ON BOILING-POINT  
Values Given Are Based upon Published Vapor-Pressure Data for the Paraffin Series. "Temperature Factor" Is the Ratio of the Absolute Boiling-Point at Given Pressure to Absolute Boiling-Point at Atmospheric Pressure

method of estimating the effect of greatly reduced pressures on the boiling-points at atmospheric-pressure. The "temperature factor" given in Fig. 7 is the ratio of the absolute boiling-point at the given pressure to the absolute boiling-point at atmospheric pressure.

#### METHOD OF USING PRESSURE-CONVERSION CHART

The use of Figs. 6 and 7 can be illustrated by an example. Assume gasoline A in Fig. 3, whose average boiling-point temperature of 50-per cent bottoms is 240 deg. Fahr. With a mixture-ratio of 12 to 1 and a manifold depression of 2.00 in. of mercury, the hydrocarbon-vapor pressure in the manifold will be 0.67 in. of mercury, as determined from the horizontal line and the scale at the left of Fig. 6. This pressure becomes 0.62 in. of mercury when reduced to 2.00-in. manifold-depression by following the horizontal line of 0.67 in. to its intersection with the vertically inclined line for 2.00-in. manifold pressure and reading the hydrocarbon pressure on the upper pressure-scale. The temperature of zero bottoms for this gasoline is 320 deg. Fahr., or 780 deg. absolute ( $320 + 460$  deg.). The temperature factor, from Fig. 7, is 0.757 at 0.62-in. pressure, and the absolute temperature is  $0.757 \times 780 = 591$  deg. absolute. The manifold temperature required for complete vaporization under these conditions is therefore estimated to be  $591 - 460 = 131$  deg. Fahr. This fuel should, therefore, produce relatively little crankcase-oil dilution at engine temperature above 130 deg. Fahr.

#### ESTIMATING TEMPERATURE REQUIRED FOR STARTING

To estimate the starting characteristics of this fuel, the temperatures giving the higher percentage of bottoms should be considered. The average boiling-point of the first 20 per cent of gasoline A to be vaporized, the temperature of 90-per cent bottoms, is 175 deg. Fahr. A liquid-fuel mixture-ratio of 4 to 1 supplied by the carburetor will, with 20-per cent vaporization, give a fuel vapor-air mixture-ratio of 20 to 1. Gasoline-air mixtures of this ratio are at about the limit of explosibility. Assuming a manifold depression of 10.00 in. of mercury during cranking, the actual hydrocarbon-vapor pressure in the engine manifold will be 0.33 in. of mercury, as indicated in Fig. 6. The temperature at which 20 per cent of gasoline A will be vaporized at atmospheric pressure is 190 deg. Fahr., or 650 deg. absolute, as shown in Fig. 3. The temperature factor for 0.33 in. of mercury and a material having a boiling-point of 190 deg. Fahr. is 0.719, in Fig. 7. The temperature necessary for 20-per cent vaporization of gasoline A at a manifold depression of 10 in. of mercury is therefore estimated to be

$$(650 \times 0.719) - 460 = 467 - 460 = 7 \text{ deg. Fahr.}$$

The nature of the continuous-distillation test, looked at from the point of view of the producer of gasoline in the refinery, is such as to suggest the possibility that the temperature which leaves zero bottoms would be nearly the same as the vapor temperature of a continuous still, provided the liquid entrainment were negligible and the vapor stream were free from steam. This might be true whether or not the vapor stream were passed through fractionating equipment. As a partial test of this possibility, two gasolines were distilled in a small still fitted with a bubble tower. One cut was made at a tower temperature of 300 deg. Fahr. and the other at 350 deg. Fahr. The results of a continuous-distillation test of these gasolines are shown in the upper two curves of Fig. 8. It will be noted that the temperatures of zero bottoms are 322 and 375 deg. Fahr., respectively. As the cuts were made direct from crude oil that contained about 1 per cent of

water, the presence of steam in the vapor stream from the tower reduced the partial pressure of the hydrocarbon vapor. Measuring the percentage of water in the overhead and computing the partial pressure of the gasoline, the temperatures of zero bottoms become 297 and 352 deg. fahr., respectively. This result may be considered a fair confirmation of the surmise that the overhead temperature of a fractionated vapor-stream will correspond closely with the temperature of zero bottoms when the tower stream is free from steam and liquid entrainment, and also that the effect of steam can be corrected with reasonable accuracy.

#### RELATION OF TEMPERATURE AND BOTTOMS PERCENTAGE

In an endeavor to obtain more information on the apparently linear relation between temperature and percentage of bottoms, a blend of equal volumes of benzol, zylol and toluol was made. The results are shown in Fig. 8, which indicates that the fractionation in the continuous-distillation apparatus is practically negligible. This lack of fractionation may explain the approximate linear relations found with gasoline and like materials.

The effect of blending is illustrated in Figs. 4 and 9. It will be noted by the second curve from the top in Fig. 4 that the 50-per cent point of the blend is the weighted mean of the 50-per cent points of the blended materials, and it will also be noted by Fig. 9 that, in the case of blends of domestic and absorption gasolines, simple arithmetical calculations will give the blended curve from the two blended materials. The temperature of 0-per cent

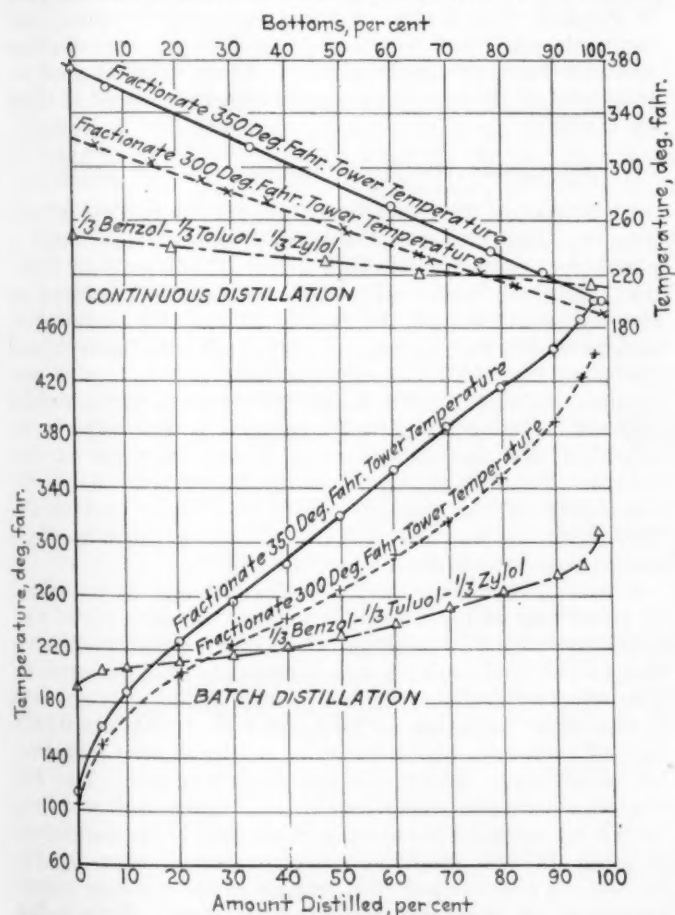


FIG. 8—TEST RESULTS FROM STILL FITTED WITH BUBBLE TOWER Cuts Were Made from Two Crude Oils, One at 300 and the Other at 350 Deg. Fahr., and from a Blend of Equal Volumes of Benzol, Zylol and Toluol. The Results Indicate That the Overhead Temperature of a Fractionated Vapor-Stream Will Correspond Closely with the Temperature of Zero Bottoms When the Tower Stream Is Free from Steam and Liquid Entrainment and That the Effect of Steam Can Be Corrected with Reasonable Accuracy

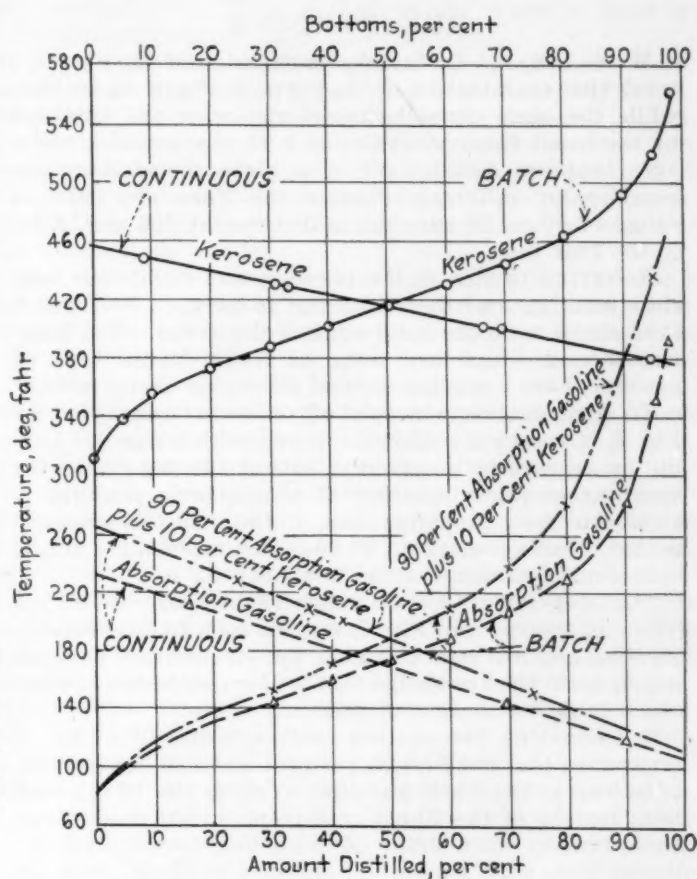


FIG. 9—RESULTS FROM BLEND OF KEROSENE AND ABSORPTION GASOLINE Simple Arithmetical Computations from the Curves of the Kerosene and Absorption Gasoline Will Give the Curve for the Blend. The Temperature of 0-Per Cent Bottoms of the Blend Can Be Computed from the Temperature of the Kerosene Curve Reduced by Partial Pressure of the Vapor of the Whole of the Absorption Gasoline. The Ready Determination of Two or Three Points on a Blended Curve, Combined with the Approximate Straightness of the Lines of Continuous Distillation, Makes the Estimation of the Volatility of Blends Comparatively Easy

bottoms of the 10-per cent kerosene and 90-per cent absorption blend can be computed from the 0-per cent-bottoms temperature of the kerosene curve reduced by partial pressure of the vapor of the whole of the absorption gasoline. The ready determination of two or three points on a blended curve from the curves of the blended materials combined with the very approximate straightness of the lines, makes the estimation of the volatility of the blends comparatively easy.

Volatility characteristics of a kerosene, as indicated by the continuous-distillation method, are also shown in Fig. 9. The distillation range is less than in the batch distillation and the line is approximately straight, as in the case of the gasoline.

Despite the very limited amount of data obtained from this method of distillation in the brief time available for this work, it is believed that simple distillation-methods for the laboratory testing of gasoline should receive serious consideration, and it is hoped that further work will be done to make the translation of boiling-points from atmospheric pressure to lower temperatures sufficiently accurate for practical purposes. It is my opinion that the use of continuous-distillation methods should give rise to the development of a definition of gasoline volatility that will be more acceptable to both producer and user than those now in vogue.

I desire to express herein my great appreciation for the support and encouragement given to this work by A. C. MacLaughlin and C. W. Stratford.

## THE DISCUSSION

W. S. JAMES:—In further explanation of the charts, I think that examination of the curve in Fig. 3 shows that, while the same general characteristics as are indicated by the usual Engler distillation hold, the actual percentages that are distilled off at a given temperature are considerably different, because the lines are flat. A range of 10 to 25 per cent is distilled at 200 deg. Fahr. in the four fuels.

Referring to Fig. 5, the paraffins and olefins are very close together over the range that is known. The benzol-zylol series is on the outer edge of the group. The hexanaphthenes, which are more of a California type of gasoline, have a peculiar sort of stuttering characteristic.

To give another example of pressure translation by Fig. 6, if you have a 12-to-1 mixture with a gasoline having an average boiling-point of about 240 deg. Fahr., the hydrocarbon-vapor pressure at atmospheric pressure is about 0.67 in. of mercury, but, if the manifold pressure is that of idling, or about 20.00-in. depression, the actual hydrocarbon pressure drops to about 0.22 in.

The step-down from atmospheric-pressure to 0.1 or 0.2 in. of mercury, in Fig. 7, may be open to considerable question and will need checking, but its accuracy depends largely upon the knowledge that we have of hydrocarbons, which is rather meager at present.

In estimating the starting characteristics of a fuel, it is assumed that the first 20 per cent distilled behaves the same way as the whole gasoline. Taking the 10-per cent point instead of the 50-per cent point, in the case of the whole fuel, as the average boiling-point, computation indicates that, with a manifold pressure of about 10 in. of mercury and a 4-to-1 mixture-ratio, which with 20-per cent vaporization would give a vapor ratio of approximately 20 to 1 in the cylinder, you would have an explosive mixture at a temperature of about 7 deg. Fahr. All of the fuels indicated in Fig. 3 are Pacific coast fuels, and gasoline A is reputed in the West to have the best starting characteristics.

When 10 per cent of kerosene is blended with 90 per cent of absorption gasoline, as in Fig. 9, the boiling-point of the kerosene is dropped to a value of about 264 deg. at the end temperature of distillation due to the complete vaporization of the absorption gasoline.

## SIMPLE MEASURE OF QUALITY NEEDED

CHAIRMAN H. M. CRANE<sup>2</sup>:—As I recollect the engineers' approach to the problem of steel specifications, it was an attempt to get away from chemical specifications and to specify steel on the basis of what it would do and not necessarily upon merely what elements it contained. That is a desirable method of approach with gasoline also. It has been very hard, however, to conceive any simply applied system of measurement that all engineers could agree would represent a real measure of what the gasoline would do in commercial motor-car engines. One of the most important questions frequently discussed by the joint Fuel Research Committee of the Society, the American Petroleum Institute and the National Automobile Chamber of Commerce has revolved around this point. We have been attempting to determine what is a good motor fuel without specifying just how it would be described, but, obviously, if we determine what it should have in it or what it should be like, unless we can also

provide a yardstick for measuring its quality that can be used by persons of ordinary intelligence without laboratory facilities, it will be very difficult to make our information 100 per cent useful to the industry.

Since Mr. James has been associated with an oil manufacturing company he has been forced to do considerable work along this line, as have all of the oil-company engineers. We are certainly indebted to him for his description of his experiments along the line of obtaining a method of measuring commercial volatility. In the old days we used to place a hydrometer in the gasoline and think that we knew all about the fuel. Our minds were disabused of that idea years ago when we found that high-specific-gravity gasoline apparently might not be so bad as we had thought it to be.

You probably have learned from Mr. James's paper some of the difficulties encountered in attempting to measure the qualities of gasoline. We had another interesting evidence of this from the work of the Bureau of Standards, on the quality of gasoline as it relates to ease of starting, as demonstrated by Mr. Sligh. We have not reached any final conclusion as a result of the tests to date; no one could, but it begins to appear that it is entirely possible that gasoline which would be particularly good for starting a cold engine in the streets of Detroit today might be inferior to some other gasoline at a warmer or colder temperature. That will have an interesting bearing, in the long run, on the supply of gasoline for use in cold weather, because it will indicate even more than has been indicated already that such variation in gasoline for climate or for a season is necessary and desirable and that we cannot produce an easy-starting gasoline for cold conditions and obtain even as good results with it during warm conditions as we used to think we could.

## MANIFOLD CONDITIONS SHOULD GOVERN TESTS

T. S. SLIGH, JR.<sup>3</sup>:—My reaction to the method of test that Mr. James has just described is that the refiner is perfectly justified in making a test of his product under the conditions under which the product is produced, so that he can interpret the results of his test in terms of results of the still operation. His statement that if, and that is a big "if", you can translate the results of continuous distillation that he has proposed into the results that would be obtained under conditions that exist in the manifold, the distillation would give a measure of fuel volatility in the engine, is perfectly correct. As to the possibility of that translation, I will leave that to Dr. Wilson, of the Standard Oil Co. of Indiana, who has done considerable work along that line.

You will remember that 5 or 6 years ago he presented at a meeting of the Society a method<sup>4</sup> of arriving at fuel volatility through the preparation of an equilibrium solution of the fuel under a vapor pressure of 1 atmosphere. You will recall, also, that the extrapolation of these data to the vapor pressures of 10 to 20 mm. (0.3937 to 0.7874 in.) of mercury, which do exist in the engine manifold, led to effective volatilities decidedly too low. The discrepancy between these results and those that were obtained by methods simulating more closely the conditions existing in the manifold was explained later by Dr. Wilson<sup>5</sup> on the basis of the change in the relative vapor-pressures of the components of the fuel. It is a big jump from 760 mm. (29.90 in.) of vapor-pressure down to 15 or 20 mm. (0.59 or 0.79 in.). It is a perfectly safe jump if you have a single definite chemical compound, but when you have a variety of compounds the relative vapor-pressures are not the same under the two condi-

<sup>2</sup> M.S.A.E.—Technical assistant to the president, General Motors Corporation, New York City.

<sup>3</sup> M.S.A.E.—Physicist, Bureau of Standards, City of Washington.

<sup>4</sup> See THE JOURNAL, November, 1921, p. 314.

<sup>5</sup> See THE JOURNAL, March, 1923, p. 287.

tions and the extrapolated pressures can be very misleading.

If it is desirable from the production viewpoint to have a test that simulates production conditions, it also seems that it is desirable from the viewpoint of the engine to have a test that simulates the condition in the engine, which is one of relatively low fuel-vapor pressure. If, instead of operating Mr. James's apparatus at a saturation fuel-pressure, that is, at a vapor-pressure of 1 atmosphere, fuel and air are fed into the apparatus in the proportions that may exist in the manifold, say a 12-to-1 ratio, evaporation will occur at much lower temperatures, and those temperatures can be translated directly into the engine condition without any approximation. Mr. James admits that. The only objection to it is that it seems to a great many that the necessary control of fuel-flow and air-flow will so complicate the apparatus as to make it unsuitable for routine laboratory testing. That is a question that cannot be argued about; a little demonstration meets considerable argument. My task is to make a study of that during the coming year.

The demonstration<sup>6</sup> in which two fuels were fed into the helices with air and the resultant air-vapor mixture was burned will be recalled. I drew attention then to the fact that, if the helix is kept at constant temperature, the air and fuel-flow controlled and the relation is obtained between the fuel feed and the bottoms or uncondensed fuel, data will be secured by which the volatility of the fuel can be calculated.

I think that a far safer method than making the jump from atmospheric vapor-pressure to partial vapor-pressure is to make the test under manifold conditions.

#### OLD LAWS OF PHYSICAL CHEMISTRY APPLIED

H. L. HORNING<sup>7</sup>:—I was interested in this subject because of Mr. James's method of approach to it. He offered to send me some fuel made by the new distillation-methods that would take advantage of the facts he has presented. It will be noted from the curves he showed that he was able to get more gasoline out of the crude. That, of course, is an interesting point. I was also pleased to hear Mr. Sligh mention the air in gasoline tests. I think that will be a step toward a system in which production tests and manifold operation will be on the continuous-distillation basis rather than on batch distillation in production and tests.

Some time ago experiments were performed in our Waukesha laboratory with apparatus in which there were two little drain pockets at the end of the manifold close to where it was attached to the cylinder. It was a hot-spot manifold, very hot. We fed 1 lb. of fuel into the engine and drained  $\frac{1}{2}$  lb. of unvaporized fuel from the manifold without any effect upon the operation of the engine. This is the equilibrium solution which is of great interest to us with respect to dilution, starting and

acceleration. This method of Mr. James's deals with fundamentals of physical chemistry.

To me, the outstanding fact in Mr. James's work is that he has put what has been known possibly for more than 100 years into practice in the refinery. What is more important, if automotive engineers would recognize the same physical laws in the design of manifolds that are used in continuous-distillation refinery-methods, some of our problems would be so simple that we would stop talking about fuel.

CHAIRMAN CRANE:—I certainly like the thought left with us by nearly Past-President Horning, that when, as engineers, we set out to design a manifold we should keep the thought firmly in mind that the fuel we are using has once been in the form of a gas.

MR. JAMES:—The question of translating the temperature of vaporization at atmospheric pressure to that at a very much reduced pressure is not answered at the present time. It might be pointed out, however, that the actual hydrocarbon-pressures in engine manifolds vary at least 500 per cent in normal engine-operation due to variation in mixture-ratio and manifold depression. This natural variation in hydrocarbon partial-pressure makes some translation of vaporization temperatures necessary in any event and also requires an arbitrary selection at test pressures. The only data that have come to my attention on such a translation of vaporization temperatures similar to those obtained with continuous distillation are given by Stevenson and Stark<sup>8</sup> and show a variation of the temperature at low-pressure vaporization of more than 20 deg. Fahr. with normal variation of mixture-ratio alone, no data being computed for changes in manifold pressure.

Working at low pressure in the starting range of gasolines will require temperatures below room temperature and will necessarily complicate the testing apparatus.

At present, a distillation at atmospheric pressure is used to select gasolines that are used at reduced pressures. If two gasolines have completely identical distillation-characteristics at atmospheric pressure, the chances are that they will have nearly identical characteristics at low pressures. This is true whether the distillation is carried out either by a batch or by a continuous distillation. The chances of such a translation being correct are much reduced when based on but a single point in the distillation range.

#### UNDERWRITING FOREIGN SECURITIES

THE figure for the total of securities publicly placed in the United States for the 4 years, 1922 to 1925, exclusive of refunding, was, according to the *New York Commercial and Financial Chronicle*, \$20,418,187,098, of which approximately \$2,978,052,000 was foreign securities and \$17,440,135,098 was domestic securities, the obligations of American States, municipalities, farm loan institutions, industrial corporations, railroads and other corporations. The percentage of the foreign securities was 14.5.

<sup>6</sup> See *THE JOURNAL*, February, 1926, p. 84.

<sup>7</sup> M.S.A.E.—President, Waukesha Motor Co., Waukesha, Wis.

<sup>8</sup> See *Industrial and Engineering Chemistry*, July, 1925, p. 675.



## APRIL COUNCIL MEETING

A MEETING of the Council was held in Detroit on April 21, those present being President Little, Past-President Horning, First Vice-President Hunt, Second Vice-President Nutt, Treasurer Whittelsey, Councilor Chandler, and F. A. Whitten, chairman of the Standards Committee. Eighty-five applications for individual membership, which had been acted on by letter-ballot of the Council, were confirmed, and in addition 121 applications were acted on at the Council meeting. The resignations of one individual Member and one Affiliate Member were accepted. Five reinstatements to membership were made; also 16 transfers in grade of membership. The mail vote of the council on six applications for Affiliate membership was confirmed, and one change in Affiliate representation made.

In the period from Jan. 1 to April 17, 1926, 304 applications for membership had been received, as compared with 262 applications received during the same months of 1925, and 189 in 1924. On April 17 there were 5573 on the rolls of the Society, including affiliate member representatives, as compared with 5312 on the same day of 1925. From Jan. 1 to April 10, 1926, 188 applicants elected qualified as members.

### COMMITTEE APPOINTMENTS

The following Standards Committee appointments were made, with assignment to Divisions as indicated:

B. H. Gilpin—Ball and Roller Bearings Division

H. H. Frey—Isolated Electric Lighting-Plant Division

A. A. Schupp—Non-Ferrous Metals Division

H. E. Fromme—Motorboat Division

H. B. Harrison, A. J. O'Neil and F. W. Stein—Production Division

W. H. Graves and E. H. Nollan—Passenger-Car Body Division

J. F. Hardecker—Aeronautic Division

C. B. Jahnke was named as chairman of the Isolated Electric Lighting-Plant Division, succeeding C. B. Dicksee.

Dr. John A. Mathews was named as a representative of

the Society on the Joint Committee on Definitions for Heat-Treatments. This committee is working under the auspices of the Society, the American Society for Testing Materials and the American Society for Steel Treating.

Various appointments were made of representatives of the Society on Sectional Committees organized under the rules of procedure of the American Engineering Standards Committee; some of these committees being sponsored directly by the Society. The names of those appointed appear elsewhere in this issue of THE JOURNAL, in the complete list of representatives of the Society on Sectional Committees.

Leonard Greenburg was named as an additional representative of the Society on the National Safety Council Committee on Hazards of Spray-Coating.

The following assignments of subjects to Divisions of the Standards Committee were made:

AN (Army-Navy) Standards—Aeronautic Division

Air Brakes and Gasoline-Electric Drive—Motorcoach Division

Grinding—Production Division

Preliminary figures were submitted of an audit of the books of account of the Society for the period Oct. 1, 1925, to Feb. 28, 1926, this being the first 5 months of the current fiscal year. The total income was \$159,806.47, the expense for the period being \$4,286.21 in excess of this amount. This is comparable with a loss of \$11,071.79 for the corresponding period of the fiscal year beginning Oct. 1, 1924. A net balance of assets over liabilities of \$148,610.78 was shown as of Feb. 28, 1926, this being \$2,271.71 less than the corresponding figure on the same day of 1925. The normal expense of the first part of the Society's fiscal year is greater than for the latter part. While the excess of expense over income this year was decidedly less than last year, the balance of assets over liabilities has been reduced owing to drastic reductions that have been made in inventory and other accounts as a result of a very thorough auditing of the books that has just been completed.

## BALANCED INDUSTRY

SINCE 1920 a farm crisis has occurred in every country of the world. It has been practically the same everywhere, and that has been the principal reason for unstable and unsatisfactory conditions in the other industries. We have been better off in this Country than they have been in any other country; our industries have been active by spells, but the buying power to maintain them in a full state of activity has been wanting. Approximately one-third of our people live on the farms, and these people have been short of buying power by reason of the low prices of what they have had to sell. That situation has improved very much in the last 18 months, and I believe that the improvement is in a large degree permanent.

About the only serious complaint from agriculture at this time is from the Corn Belt. This is that the price of corn is low; and that is so, but the reason for it furnishes another illustration of what I mean by balanced industry. Last year the corn crop was short and the price was high. The regular régime of agriculture in the Corn Belt was upset. The chief use for corn out there is to make pork, and when the farmers did not have the corn they sold down their breeding stock. Now they have a big crop of corn and a short crop of hogs, and the price of corn naturally falls. Hogs are bringing a big price because of the scarcity. The farmers who hung on to their breeding stock last year and raised a good crop of pigs are reaping a harvest; but the farmers who have corn

and no hogs have to sell their corn for what they can get. The long and short of it is that corn and hogs are out of balance this year and the corn has to be carried over until more hogs are raised to eat it. That is a temporary condition, and it does not affect all of the farmers in the United States by any means.

In general, the industries of this Country are in a fair state of balance at this time, business is generally prosperous, and no reason why we should not have a healthy state of prosperity for an indefinite time is in sight. Some people are very much afraid that when the industries of Europe are fully restored we shall have to meet very severe competition, but they forget that if Europe's industries are busy the people will have greater buying power. They will want more of our cotton, our copper, our meats, and other products, which will mean greater prosperity for our farmers and greater buying power at home. It would be good if we could bear in mind always that the purchasing power of every country is in its own powers of production. People buy with what they sell, and the highest state of prosperity for every country is to be had when other countries are prosperous. Prosperity does not consist in having good times at the cost of other peoples, but in great production and great consumption everywhere, a balanced state of industry in which we exchange goods profitably with each other.—G. E. Roberts in *American Bankers Association Journal*.



# Aircraft-Engine Relations to the Needs of Naval Aviation

By LIEUT. HUGO SCHMIDT, U. S. N.<sup>1</sup>

SOUTHERN CALIFORNIA SECTION PAPER

Illustrated with CHART

## ABSTRACT

AIRPLANES for training, for observation or spotting, for fighting, for three-purpose or combined torpedoing, bombing and scouting, and for patrol duty constitute the five types employed by the Navy for comprising in as few types as possible all the fighting characteristics desired, and the author states the important features of each type. Regarding the size and weight of each type, excepting patrol airplanes, very definite limits are imposed by stowage space, crane and elevator capacities, catapult and deck facilities on shipboard for taking the air, and the space available for landing on aircraft carriers. Size, weight and speed of naval airplanes must be brought into agreement and, since only a certain number of types of airplane having definitely limited sizes and weights can be built, all types must conform to set standards. Because the Navy has been forced to employ smaller aircraft than can be used ashore, it is necessary to overcome this disadvantage by making very marked improvements in powerplants, and the requirements of aircraft engines are enumerated, special emphasis being placed on those of the fixed-radial air-cooled engine.

Discussing the respective merits of air-cooled and water-cooled engines for aircraft, the author states that, up to about 450 hp., the radial air-cooled engines developed by the Navy have had a decided advantage in weight per horsepower. Comparative ratings on a basis of pounds per horsepower when ready to fly are mentioned. In the 220-hp. class, the Wright J-4 air-cooled engine weighs 2.55 lb. per hp. and the Wright E-4 water-cooled engine weighs 3.75 lb. per hp. This is a total saving of 264 lb. in gross weight for the J-4 engine. In the 350-hp. class, the Wright R-1200 air-cooled engine weighs approximately 2.4 lb. per hp. against 3.1 lb. per hp. for the Curtiss D-12 water-cooled engine and effects a gross saving in weight of about 245 lb. Saving in weight diminishes as higher engine-powers are reached. The 450-hp. Wright P-2 air-cooled engine weighs about 2.3 lb. per hp., and the 500-hp. Packard 1A-1500 water-cooled engine weighs 2.4 lb. per hp., or practically the same weight per horsepower.

Defining the term "brake mean-effective pressure" as the average effective pressure that, if applied to the piston in each cylinder, will produce the given horsepower, the author passes to a discussion of the fuel consumption of both air-cooled and water-cooled engines and the service acceptability standards for aircraft engines. The advantages of the air-cooled aircraft-engine are enumerated and radial air-cooled-engine construction is outlined. In the future design of aircraft, the Bureau of Aeronautics intends to develop most of its airplanes about three types of radial air-cooled engine. Training airplanes will be built-up around the Wright J-4 220-hp. engine. The Wright R-1200 engine, of 350 hp., will be the nucleus for single-seat fighting airplanes and two-place convertible observation-airplanes for shipboard use. The Wright P-2 engine, of 450 hp., will be employed in both single and twin-en-

gine three-purpose airplanes. For patrol airplanes, the water-cooled engine is still the only one to fulfill the requirements; but, with the foregoing exception, it has been found that three engines—the 220-hp. engine of 800-cu. in. volumetric-displacement, the 350-hp. engine of 1200-cu. in. capacity and the 450-hp. engine of 1600-cu. in. capacity—will develop sufficient power to give high performance and, at the same time, keep the gross weight down to Navy requirements.

NAVAL-AVIATION problems differ from those of military aviation. The limitations of weight and space imposed upon naval aircraft by the size of carriers or by the space available on battleships, cruisers and other fighting craft, are very inimical to the best performance-characteristics. This forces the Navy to effect a compromise between the number of types of airplane desired, the size and weight of these types and the best performance for the missions to be undertaken.

While there are many types of airplane in the Army Air Service, such as those for attack, for pursuit, for corps observation, for day bombing, for night bombing, and the like, the limitation of armaments imposed upon the Navy allows only a definite number of combatant ships capable of carrying aircraft and this requires the Navy Air Service to combine all the fighting characteristics desired in as few types as possible. The number of types at present is five; namely, airplanes for training, for observation or spotting, for fighting, for three purposes or combined torpedoing, bombing and scouting, and for patrol duty.

The training type of airplane is not limited as to space or weight characteristics, since it ordinarily would be operated from a shore base. For primary training it is desirable to have a low-powered, very stable airplane with a slow landing-speed. For advanced training, types similar to those in actual service probably would be employed.

The observation or spotting airplane should have the best possible radius of action, height of ceiling, rate of climb, and maneuverability consistent with the primary requisites of good communication-facilities, clear observation and defensive armament.

Fighting airplanes necessarily must have the best possible high speeds, offensive armaments, maneuverability, rate of climb, and height of ceiling, even though the radius of action is limited.

The three-purpose airplane must have a very high lifting-capacity and be capable of carrying large military loads, whether of fuel, bombs or torpedoes, combined with defensive armament. This can be obtained by sacrificing maneuverability, high speed and height of ceiling somewhat.

Patrol airplanes are usually large boat-seaplanes similar to the PN type used for the Hawaiian flight and generally mounting two or more engines. Since their mission involves a large radius of action over the sea, they must be very seaworthy and have defensive arma-

<sup>1</sup>Naval Air Station, San Diego, Cal.

ment. This calls for a decided compromise with speed, rate of climb and height of ceiling.

#### SIZE AND WEIGHT CONSIDERATIONS

Regarding the size and weight of all types except the patrol airplane, very definite limitations are imposed by stowage space, crane and elevator capacities, catapult or deck facilities on shipboard for taking the air, and the space available for landing on aircraft carriers. The fundamental equation of lift for aircraft shows that the speed of level flight varies directly as the square root of the weight and inversely as the square root of the wing area; and, since the landing speed of aircraft is determined by the space available for landing or the momentum to be absorbed by the arresting gear of aircraft carriers, one finds that weight and wing areas are at loggerheads with each other. This calls for a careful compromise so as to bring the size, weight and speed into agreement. Since only a certain number of types of airplane with definitely limited sizes and weights can be built, all types must conform to these set standards.

With all the obstacles presented, many refinements must be employed to attain the performances required for the missions to be undertaken. The consensus of opinion among the best aeronautical engineers of this Country seems to be that the present maximum performance of heavier-than-air craft possibly can be increased by as much as 30 per cent over an indefinite number of years. This increase may be obtained by the use of lighter structural materials or by possible improvements in aerodynamic characteristics, such as better streamlining, wing contours, balance, control, and the like, but that the primary consideration must be given to engine development, which will involve less weight per horsepower, lower specific fuel-consumptions and greater reliability of powerplants.

Since the Navy has been forced to employ smaller aircraft than can be used ashore, it is necessary to overcome this disadvantage by very marked improvements in powerplants. The lowest possible power must be used that is consistent with the particular performance or mission of the airplane. This involves not only the weight of the powerplant but also the weight of the fuel necessary, both of which are reflected in the gross weight of the airplane structure. To meet these requirements best the Bureau of Aeronautics in the Navy has been steadily working for the last 4 years on the development of fixed-radial air-cooled engines to meet all service requirements so far as possible.

#### AIRCRAFT-ENGINE REQUIREMENTS

Definite reasons exist for the choice of air-cooled rather than water-cooled engines but, before explaining these reasons, it is well to state the general requirements of aircraft engines. They must

- (1) Be capable of running at full power for long periods and yet have the lowest possible weight per horsepower consistent with reliability and ruggedness
- (2) Have the highest possible dependability and endurance with the lowest possible specific fuel-consumption
- (3) Be flexible and controllable at all speeds from idling to full throttle, on account of the requirements of formation flying and missions calling for varying cruising-speeds
- (4) Be easy to overhaul and to maintain
- (5) Have interchangeability of all parts among engines of the same model
- (6) Have vibration practically eliminated so as to

keep down the weight of the engine structure and supports

- (7) Occupy the minimum volume, create the minimum head-resistance and be easy to cowl
- (8) Be as short in length as possible, to concentrate the center of gravity in such a position as to keep the fuselage to maximum shortness in length for maneuverable and structural reasons, and also because short engines are inherently stiffer in the crankcase than longer ones. Short engines are necessarily lighter and more rugged and reduce the multiplicity of engine parts
- (9) Be capable of being built cheaply in quantity production in the shortest time possible

#### AIR-COOLED VERSUS WATER-COOLED ENGINES

If one could assume equal durability, flexibility and fuel economy, the air-cooled engine would be more advantageous than the water-cooled type due to the elimination of the weight and the complications imposed by radiators, piping and water. The supposedly large parasite resistance of the radial air-cooled engine is in reality no more than the head-resistance of the radiator and cowl of the water-cooled engine. Streamlining behind an air-cooled engine often can be carried out more advantageously, since the cylinders are the only projections beyond the cowl.

The most annoying source of trouble in water-cooled aircraft-engines is leaky water-jackets during flight. They make the water-cooled cylinder more vulnerable to machine-gun fire. When any cylinder goes bad, the flight is ended. This is not necessarily true with air-cooled engines. Recently, a radial air-cooled engine in flight was observed to have one cylinder-head cracked, although the engine was apparently running well. The pilot landed and found that the exhaust-valve retainer on that cylinder had come adrift, allowing the exhaust-valve to drop into the cylinder. He removed the valve-gear from the cracked cylinder and continued his flight, with remarkably smooth running, on the remaining eight cylinders. This characteristic of air-cooled engines to function in spite of cylinder damage, due to the elimination of elaborate overhead-camshaft gear, is a decided advantage.

Up to about 450 hp., the radial air-cooled engines developed by the Navy have had a decided advantage in weight per horsepower, as can be seen from the curves in Fig. 1. It has heretofore been the practice to rate water-cooled engines as regards weight per unit of power on a dry basis, less the radiators, water and piping. Since this is misleading, a better method is to classify them on a basis of pounds per horsepower, ready to fly. The following ratings are on the latter basis. In the 220-hp. class, the Wright J-4 air-cooled engine weighs 2.55 lb. per hp. and the Wright E-4 water-cooled engine weighs 3.75 lb. per hp. This is a total saving of 264 lb. in gross weight for the J-4 engine. In the 350-hp. class, the Wright R-1200 air-cooled engine weighs approximately 2.4 lb. per hp. against 3.1 lb. per hp. for the Curtiss D-12 water-cooled engine and effects a gross saving in weight of about 245 lb.

Saving in weight diminishes as higher engine-powers are reached. The 450-hp. Wright P-2 air-cooled engine weighs about 2.3 lb. per hp. and the 500-hp. Packard 1A-1500 water-cooled engine weighs 2.4 lb. per hp. or practically the same weight per horsepower. This reduction in weight per unit of power in the latter case has been accomplished by adopting a higher number of revolutions per minute and the use of reduction gears. At present, for powers in excess of 500 hp., the water-

cooled engine still reigns supreme due to higher rotative speeds and reliable light reduction-gears. In general, the higher temperatures of air-cooled cylinders have resulted in lower brake mean-effective pressures and economy for high powers, and high rotative-speeds in static radial-engines have been limited by the so-called connecting-rod "big-end" conditions.

The term "brake mean-effective pressure" means the average effective pressure that, if applied to the piston in each cylinder, will produce the given horsepower. It is not expected that the next few years will witness anything revolutionary in design, although steady improvement is going on in closer thermal-contact between steel cylinder-liners and aluminum heads, more careful valve-seat cooling, proper combustion-chamber form, better carburetion, and more advantageous spark-plug location.

#### FUEL CONSUMPTION AND SERVICEABILITY

The specific fuel-consumption of both water-cooled and air-cooled engines is now around 0.5 lb. per b.hp-hr. This factor depends largely upon compression-ratios which are limited by detonating or "pinking" conditions and the necessity for using blended fuels, which are often difficult to obtain. Benzol has been used very successfully but weighs more than gasoline and also tends to solidify in cold weather. The average compression-ratios of the recent engines are in the neighborhood of 5.5 to 1.0.

As early as the beginning of 1922, the Navy increased the standard of service acceptability for aircraft engines from a 50-hr. test-run to a 300-hr. test-run of three 100-hr. periods of continuous running at full power on the test-stand. An experienced pilot would never approximate these conditions in flight as he would maintain only enough power to perform his mission and, except for "take-offs," racing and formation flying, rarely would fly at full throttle. On the other hand, an engine in flight often is subjected to sudden altitude and climatic changes. This higher standard, however, forces both air-cooled and water-cooled engines to greater reliability, ruggedness and endurance.

Several water-cooled engines of the Wright T-2 design have been flown in the Scouting Fleet for almost 300 hr. without overhaul, at the end of which time an inspection showed that they could have been run considerably longer. This record has not been met in service by air-cooled engines, although many have been operated by the Battle Fleet and turned-in for routine overhaul after from 150 to 200 hr. of flight. Upon dismantling, these engines were found to be still in excellent condition, requiring only minor top-overhaul such as grinding valves and renewing piston-rings to make them as capable as ever. When one considers that, up to a few years ago, such tried and proved engines as the Liberty-12 and the Hispano-Suiza had an average maximum life of 100 hr. between major overhauls and that the radial air-cooled engine is very recent and less conventional in design, greater reliability is to be hoped for in the future.

#### AIR-COOLED-ENGINE ADVANTAGES

The thermodynamics of air-cooled-engine design appear to be as sound as those of water-cooled engines, and the troubles encountered have been largely mechanical. Nothing inherent exists in the air-cooled engine to make it less durable or dependable than the water-cooled engine. It is less sensitive to sudden heat or cold, is easier to start and requires less warming-up in cold weather, the last feature being very desirable in the alert type of airplane. It is not subject to boiling-over when

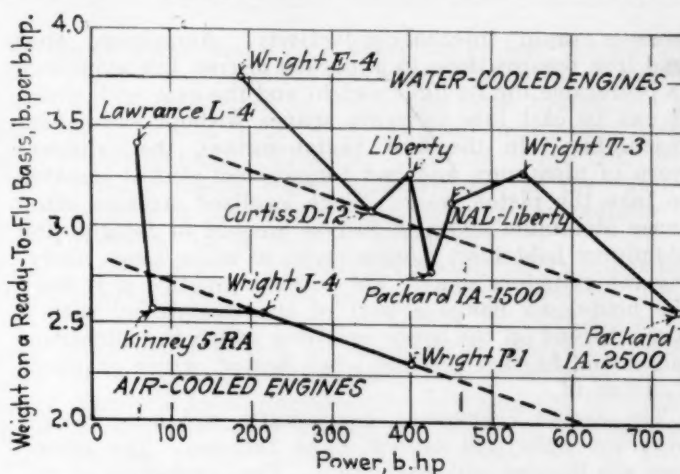


FIG. 1—WEIGHT PER HORSEPOWER OF AIRCRAFT-ENGINES FOR NAVY USE

Curves Show the Decided Advantage in Weight per Horsepower, Up To About the 450-Hp. Class, of the Radial Air-Cooled Aircraft-Engines Developed by the Navy. It Has Heretofore Been the Practice To Rate Water-Cooled Engines As Regards Weight Per Unit of Power on a Dry Basis, Less the Radiators, Piping and Water. Since This Is Misleading, a Better Method Is To Classify Them on a Basis of Pounds Per Horsepower When Ready to Fly

climbing steeply in hot weather or when operating in tropical climates. The oil never heats unduly and always remains at working temperatures.

Top overhauls are easier to make. The grinding of valves involves only the removal of a cylinder and the touching-up of the valves, with no change in timing. Water-cooled engines, as a rule, require either the removal of the engine or the dismantling of the camshafts and valve mechanism, and that the entire engine be retimed upon reassembly. The ability to effect quick repairs is a decided advantage in seaplane operation.

Due to the reduction in the number of parts, the radial air-cooled engine usually can be built more cheaply than can the water-cooled engine, with its complicated auxiliaries and piping, and lends itself better to quantity production. The tendency in water-cooled engines is toward block construction to give a more rigid and a lighter structure. This involves the rejection of an entire block for the defect of a single cylinder, a condition not encountered in radial engines.

It is well to point out here that air-cooled engines in aviation are not restricted to fixed-radial and to rotary types. A Liberty-12 engine has been successfully air-cooled by the Army Air Service at McCook Field, Dayton, Ohio. This engine developed slightly more than its rated horsepower as a water-cooled engine. It had a tendency to over-cool rather than to under-cool. The change from water-cooling to air-cooling consisted primarily in the substitution of air-cooled cylinders for the regular ones and the interchanging of the exhaust and the inlet-valves.

#### RADIAL AIR-COOLED-ENGINE CONSTRUCTION

The scope of this paper does not permit an extensive discussion of the construction of the radial air-cooled engine; so, only a brief summary of some of the more interesting features will be presented.

Air-cooling is accomplished by causing the air to strike the cylinders laterally at right angles to the cylinder axes, which involves circumferential finning. This makes the cylinders easy to cast and to machine, furnishes strength against internal pressure and allows the maximum cooling-surface on the ports and on the combustion-chamber. The material used must have a high rate of heat transfer from the surface to the air and also must

possess rapid internal-conductivity. Aluminum, steel and iron possess these to a marked degree, but aluminum is preferable for its light weight and the ease with which it can be cast into intricate shapes without subsequent machining. In the first radial-engines, the cylinders were of aluminum and had forged-steel sleeves inserted to take the piston wear. Since localized stresses often cause aluminum alloys to fail on account of fatigue, the aluminum hold-down flanges broke in many cases, carrying the cylinders away. The present practice is to have the hold-down flange a part of the steel liner, with a screw thread on the upper end over which the aluminum jacket and fins are screwed when heated, which produces a shrink fit.

The earlier crankcases, crankshafts and master rods were too light and caused many failures. The newer ones are heavier and more rigid. The crankshaft of the radial engine is better adapted by virtue of its length to withstand torsional vibrations from firing impulses.

To assist in weight reduction, recent experiments have been made with a view toward replacing the conventional aluminum-pistons for aircraft usage with pistons made of an alloy composed of 87 per cent of magnesium and 13 per cent aluminum. Magnesium seems to stand-up better under detonating conditions than aluminum; but, to date, the experiments have not progressed to an extent sufficient to warrant the supplanting of the aluminum piston. It is readily appreciated that a distinct saving in weight would be effected.

Valve seats are ordinarily of aluminum bronze, so that the coefficient of expansion will be very similar to that of the aluminum head itself. The earlier seats had a tendency to work loose in service and to cause a loss in compression. They are being inserted more carefully and rolled-in at present, not only to produce tightness but also to assure better thermal-contact. While inlet-valves usually are of case-hardened or of tungsten-alloy steel, the exhaust-valve material must be selected very carefully to give great strength at high temperatures and also to resist the erosive effect of the hot exhaust-gases. The present tendency is to use tulip valves of steel alloyed with silicon and chromium and commonly known as Silchrome valves.

Rocker-arms and push-rods are heavier than formerly, but this runs into increased weight and has not entirely obviated the difficulties. To eliminate these defects an oleo or hydraulic valve-gear is being developed successfully. One great defect with the present type of open valve-gear is that, when operating in seaplanes, the salt spray strikes the cylinders and tends to warp the valves. This often causes the intake-valves to warp sufficiently to allow a backfire through the carbureter which causes several charges of dead gas into the other cylinders. This defect could be overcome only by continuous priming until the airplane actually was in the air. With hydraulic valve-actuating mechanism, it should be very easy to house the valve-gear and to eliminate this difficulty. For higher powers, resort must be made to liquid cooling for exhaust-valves. The oleo valve-gear should be well adapted for this purpose.

Due to the short length of the crankshaft, roller bearings must be employed as main bearings in addition to the ball thrust bearings. The objection to most anti-friction engine bearings is that the condensate from the exhaust gases in the crankcase tends to corrode the polished surfaces. This is only encountered in the thrust bearings, as the main bearings are amply lubricated. The master-rod bearings are now babbitt lined, steel backed and have had immediate success, being

much stiffer than the earlier types. Bearings must be stiff to avoid deflection and local high-pressures.

#### NAVY RADIAL-ENGINES

The first of the Navy radial-engines had three carbureters. It was found almost impossible to synchronize the mixtures of all the carbureters for all speeds, so the single carbureter was adopted. This engine proved decidedly superior in idling characteristics and, at the same time, gave the same number of revolutions per minute at wide-open throttle. The latest radial engines are being equipped with a rotary induction-system or low-pressure supercharger. This consists of a fan driven by gearing from the engine and placed between the carbureter and the intake-manifold. It overcomes the resistance in the induction system, supplies the cylinders with a larger charge and results in improved volumetric efficiency. At the same time it mixes the charge better, increases the temperature and causes improvement in vaporization. Since the pressure rise overcomes the loss in charge weight due to the temperature rise, much better distribution is obtained. This is not to be confused with the high-pressure supercharger used for altitude flying. The latter is necessary for supplying a greater volume of air to the carbureter in rarefied atmosphere, while the former tends to increase power and give better specific fuel-consumption at sea level and at small altitudes.

The necessity for great-altitude superchargers can be realized from the fact that the 400-hp. Liberty-12 engine at 25,000-ft. altitude develops only about 71 hp. without the supercharger. It must be remembered, however, that the supercharger or compressor to remedy this condition adds considerable weight and requires about 43 hp. for its operation, being usually driven by gears meshing with the engine shaft.

In connection with radial engines in tractor airplanes, it has been observed on occasions that pilots have felt groggy and nauseated after a long flight. This is because they are surrounded by the exhaust gases from the engine. It may be necessary to adopt a common exhaust-manifold with a long single or double exhaust-pipe.

At present, high-tension ignition-leads are enclosed in circular manifolds, because those in earlier engines often became oil-soaked and short-circuited. Spark-plugs are now screwed into bronze bushings secured in the cylinder castings, instead of being screwed directly into the castings, as formerly. This prevents the threads from stripping and the plugs from blowing out. For seaplane operation, it is very desirable to make the plugs waterproof. For ease in timing, recent engines have been made adjustable to such an extent that the timing can be changed when the engine is completely assembled through an opening in the front of the case.

Although very little detailed design has been touched upon, it is evident that remarkable advances have been made in air-cooled engines within the last 3 years. In the future design of aircraft, the Bureau of Aeronautics intends to develop most of its airplanes about three types of radial air-cooled engine. Training airplanes will be built-up around the Wright J-4 220-hp. engine. The Wright R-1200 engine, of 350 hp., will be the nucleus for single-seat fighting airplanes and two-place convertible observation-airplanes for shipboard use. The Wright P-2 engine, of 450 hp., will be employed in both single and twin-engine three-purpose airplanes. For patrol airplanes, the water-cooled engine is still the only one to fulfill the requirements; but, excepting the last, we find

## NEW YORK CITY'S TRAFFIC PROBLEM

513

that three engines—the 220-hp. engine of 800-cu. in. volumetric-displacement, the 350-hp. engine of 1200-cu. in. capacity and the 450-hp. engine of 1600-cu. in. capacity—will develop sufficient power to give high performance and at the same time keep the gross weight down to Navy requirements.

## THE DISCUSSION

QUESTION:—Are efforts being made in the development of air-cooled engines toward using a higher compression-ratio than 5.5 to 1.0?

LIEUT. HUGO SCHMIDT:—Yes, but I believe they have not been successful as yet. Detonation occurs at that time, and non-detonating fuel is not available. Airplane fuel has its disadvantages. Benzol mixed with gasoline is fairly successful but not entirely so. Blended airplane-fuel often consists of 60 per cent of aviation gasoline and 40 per cent of benzol.

A. H. LACEY:—Have you observed any attempt to use thermostat regulation in water-cooling, or have you had opportunity to compare the result in warming-up quickly under such conditions with an air-cooled engine?

LIEUTENANT SCHMIDT:—Thermostats have not been used, to my knowledge; shutters have been used instead. When it is being warmed-up, every engine has the shutters closed until it reaches the proper running-temperature, and it is warmed-up while using a non-retarded spark.

MR. LACEY:—In that connection, if thermostats were

<sup>2</sup> Consulting engineer, C. & L. Six Wheel Truck Co., Los Angeles.

used there would be a considerably less volume to heat as, if I understand it correctly, when using the shutters, the entire volume of water has to be heated and would be circulated through the radiator during that time.

LIEUTENANT SCHMIDT:—That is true; but, even at great altitudes, where water freezes, all the water must be kept in circulation. The water in the radiator might freeze at an altitude of 28,000 ft.

MR. LACEY:—The shutter system offers important advantages and is not to be decried; however, I believe it possible to arrange a system of circulation with a thermostat so that all the water is always in circulation in accordance with the maximum capacity of the pump. This can be accomplished by utilizing the thermostat to bypass the water around the radiator, but leaving the bottom of the radiator in communication at all times with the suction side of the circulating pump. With such a system, whenever all the circulating water is being bypassed, the radiator is drained approximately dry; however, if conditions were such that the larger part of the water were bypassing, and that a small part were still flowing through the radiator, it is possible that freezing in the radiator will occur under extremely low temperature-conditions, although experience may show that freezing will be a rare occurrence under any conditions. If so, it seems that such a system would have merit in taking care of the maintaining of a proper water-temperature automatically, using comparatively simple and light-weight apparatus. Naturally, to be entitled to serious consideration, any apparatus designed for use in aircraft work must be reliable.

## NEW YORK CITY'S MOTOR TRAFFIC PROBLEM

(Concluded from p. 500)

Present building-height limitation is entirely inadequate to prevent resulting street congestion.

Bypass highway routes must be provided around the central business district.

There are many important intersections in the outskirts of the region where a separation of highway grades can be carried out at reasonable expense.

Street arcades are best adapted to relatively narrow streets, where the cost of widening would be prohibitive

## FUTURE-TRAFFIC ESTIMATES

The future amount of traffic on the principal highways was estimated in three ways:

- (1) By distribution method based on routing vehicular traffic from each county to every other county, the amount of traffic being a function of population and distance
- (2) By establishing a relation between traffic and automobile registration and applying this to future registration estimates
- (3) By establishing the relation between traffic and time, and carrying this forward over a number of years

The results of estimating the future amount of highway traffic indicated that in the 43 years from 1922 to 1965 this will increase in the separate counties from 2.4 to 9.6 times. The greatest increases of traffic will be in those counties immediately outside of the central congested area. Traffic on the exits and entrances to the central area has been doubling every 4 to 8 years, but it is not probable that such rates of increase will continue.

The lane capacities of various types of street vary from 400 to 1500 vehicles per hr., in accordance with the width and nature of the street. Provision on arterial routes in the suburban areas for maximum Sunday-traffic, with all parking prohibited, is practically equivalent to providing for the maximum business-day traffic, with the outside lanes reserved for parking or unloading of vehicles.

The estimated traffic for the year 1965, along or parallel to the present four principal arterial routes on Long Island, is about twice what these highways could carry if developed to their full roadway capacity, and almost  $3\frac{1}{2}$  times the present capacity of the seven principal routes. It is estimated that there must be carried in the year 1965, on or parallel to the seven principal arterial routes in Metropolitan New Jersey, more than  $3\frac{1}{2}$  times their present capacity. The estimated 1965 traffic, on or parallel to the existing nine arterial routes in southern Westchester County, is about 3 times their present maximum capacity.

Traffic on the Manhattan avenues crossing 48th Street will reach a point of saturation by about the year 1930, and that on the avenues crossing 28th Street will reach saturation by about 1934, even if the present proposals for increasing the roadway capacity in these avenues are carried out.

It will be seen that the subject of communication facilities in New York City is a complicated one. Of course, this report is not intended to offer specific proposals for the solution of the intricate problem involved, but it does indicate in a masterly manner the difficulties as well as point out methods by which some of the difficulties can be overcome. Also, it gives most pertinent and interesting data for the consideration of those engaged in traffic studies of motor-vehicle operation.

# Society Representatives on Sectional Committees

SINCE the organization of the American Engineering Standards Committee in 1918, the Society has taken an increasingly active part in this work. The American Engineering Standards Committee was organized to serve as a national clearing house for engineering and industrial standardization and through its organization and procedure correlate engineering and industrial standardization on a national basis. It also serves as the principal point of contact for the consideration of international standardization that has begun to assume important proportions in the last few years.

To provide an adequate system for the correlating of the various standardizing activities in the United States in an organized way, the rules of procedure under the American Engineering Standards Committee were formulated, which provide for the designating of selected technical societies and industrial associations to act as sponsors for the various standardization projects. The sponsors for such projects organize nationally representative committees known as Sectional Committees, which do the actual work of standardizing under the administrative direction of the sponsors. When reports by Sectional Committees are completed, they must first be approved by the sponsors and then submitted to the American Engineering Standards Committee, which comprises representatives of the member societies and associations, for final approval as American or tentative American standards. The American Engineering Standards Committee does not pass upon the substance of Sectional Committee reports, such approval relating only to whether the Sectional Committee was adequately representative of all interests and whether it has conducted its work in a sufficiently broad and comprehensive manner. At this time there are 35 national organizations included in the 24 member bodies forming the American Engineering Standards Committee. Eighty-two standards reported by Sectional Committees have been approved and 212 are officially in progress grouped under the following general classifications: civil engineering and building trades, mechanical engineering, electrical engineering, automotive engineering, transportation, shipbuilding, ferrous metallurgy, non-ferrous metallurgy, chemical industry, textile industry, mining, wood industry, pulp and paper industry, glass and pottery and miscellaneous.

The Society's representatives on Sectional Committees for which it is a sponsor or on which it is represented are as follows: For personnel of the S. A. E. Standards Committee refer to the March, 1926, issue of THE JOURNAL, p. 299.

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515

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**FREDERICK E. MULLER**


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**F**OLLOWING an illness of 10 days, caused by a heart attack, Frederick E. Muller died on Feb. 25, 1926, at his home in Mount Vernon, N. Y., at the age of 52 years. He was a stockholder and director of the Norma-Hoffmann Bearings Corporation, Stamford, Conn., at the time of his death and had been factory manager of the Corporation continuously from the time he entered its employ in 1912.

Mr. Muller was born at Aix-la-Chapelle, France, on Oct. 18, 1873, and, after 8 years at high school, received 2 years' training at the technical school in Elberfeld, Germany, and

supplementary technical education at L'Ecole Arsemetier, Paris. Prior to coming to the United States, he was in charge of tool designing successively for Panhard & Levassor and the Société Française de Thompson-Houston, in France, and general manager for G. Gnauk, Barcelona, Spain. His first connection in America was with the Mercur Mfg. Co., maker of ball bearings, as general manager. He specialized in the design of magneto ball bearings and machinery.

Mr. Muller was elected to Member grade in the Society on July 26, 1911.



# The Practical Application of Superchargers to Automobile Engines

By C. W. ISELER<sup>1</sup>

ANNUAL MEETING PAPER

Illustrated with CHARTS

## ABSTRACT

**P**ROGRESS has been made steadily in the application of superchargers to racing automobiles, and the author of the following paper has no doubt that the supercharger will be adopted as standard equipment on passenger automobiles of the better class within the next few years. Builders of the Mercedes car have placed on the market two models regularly equipped with a supercharger of the Roots blower type, and the increased power, flexibility and speed of these cars have shown the public the great possibilities obtainable by the supercharger.

In addition to the foregoing advantages, the supercharger gives greater mechanical efficiency and fuel economy. Moreover, the engine can be made smaller, the compression can be well below that at which detonation occurs and still afford a surplus of power, heat losses in the water-jacket are reduced because of the larger charges of mixture in the cylinders, expansion of the gas can be utilized more fully by opening the exhaust-valves later, the engine can be made quieter by lifting the inlet-valves more gradually, and wear can be reduced by using lighter valves and valve-operating mechanism.

The smaller engine develops sufficient power at nearly full load to drive a car at constant speed on a level road and the supercharger is the means of providing excess power for acceleration and hill-climbing. It is shown that the average American automobile engine can develop power greatly in excess of that needed to drive it at constant speed on the level road and that fuel consumption increases rapidly as the load on the engine is decreased from three-quarter load, as when throttled. The mechanical efficiency also is much lower at partial load.

The problem involved in designing an automobile supercharger is to introduce a larger charge of mixture in the time allotted by the timing diagram, thereby maintaining full volumetric efficiency at the higher engine-speeds and increasing the power output. Area of valve opening cannot be increased materially, hence it is necessary to force the larger charge into the cylinders under pressure. To avoid too high a compression-ratio, the ratio can be decreased and the engine supercharged only enough to give the original final pressure.

The Mercedes supercharged engine is described briefly and the performance of the car with and without the supercharger is analyzed. The analysis and comparison of power curves show that acceleration from 10 to 30 m.p.h. is much more rapid with the supercharger, in both high and intermediate gear the maximum speed is increased from 40 to 50 per cent, the unsupercharged engine has the characteristics of a low-speed engine and the supercharged engine those of a high-speed engine, the size of the manifolds and valves has been reduced, the supercharger maintains approximately 100-per cent volumetric efficiency at maximum engine speed, and the thermal efficiency is in-

creased. Power required to drive the supercharger is calculated to be 10.1 hp.

As the Mercedes supercharger does not begin to function at the lower car-speeds, no increase of engine torque due to the supercharger can be expected at these speeds, hence the car is provided with full change-speed gearing. It may be that sometime a supercharger will be developed which will supply at low speeds the additional torque that is now provided by the change-speed gears and thereby make it possible to dispense with the transmission, as some authorities believe can be done when a supercharger is installed.

**S**TEADY progress has been made in the application of superchargers of various designs to racing cars and undoubtedly it will not be long until devices of this kind are adopted as standard equipment on passenger automobiles. The builders of the Mercedes car in Germany have placed on the market two models of automobile of 24-100 and 33-140 hp. equipped with a supercharger of the Roots blower type as standard equipment. The increased power, greater flexibility and higher speed obtained with these cars, both in Europe and America, have shown the public the great possibilities obtainable by the supercharger on passenger cars. In the following paper will be shown briefly the advantages that can be gained by the supercharger, followed by an analysis of the problems involved in the supercharger, quoting as an example the results obtained in the Mercedes car.

Advantages gained by the use of the supercharger are increase in (a) power, (b) mechanical efficiency, (c) flexibility, (d) fuel economy, and (e) speed. Furthermore, it is possible to build the engine with a compression-ratio that is lower than the highest possible ratio that can be used without detonation and yet obtain a surplus of power. The temperature at which detonation occurs is constant for each fuel and mixture. The temperature of the mixture at which it could enter the cylinder at different compression-ratios without reaching the detonation temperature can be determined for each fuel from the formula

$$T_a = T_c / \epsilon^{\gamma-1} \quad (1)$$

where

$\epsilon$  = the compression-ratio

$\gamma$  = the coefficient of compression and expansion obtained from the polytropic relation  $p v^{\gamma-1} = \text{constant}$

$T_a$  = the absolute temperature of the mixture at the entrance of the cylinder

$T_c$  = the highest possible absolute temperature after compression

From this consideration it is evident that the entrance temperature of the mixture should be kept as low as possible to utilize the highest possible compression-ratio without danger of detonation. For this reason it is absolutely necessary to provide an intercooler between the supercharger and the engine to neutralize the rise

<sup>1</sup> Research engineer, General Motors Corporation Research Laboratories, Detroit.

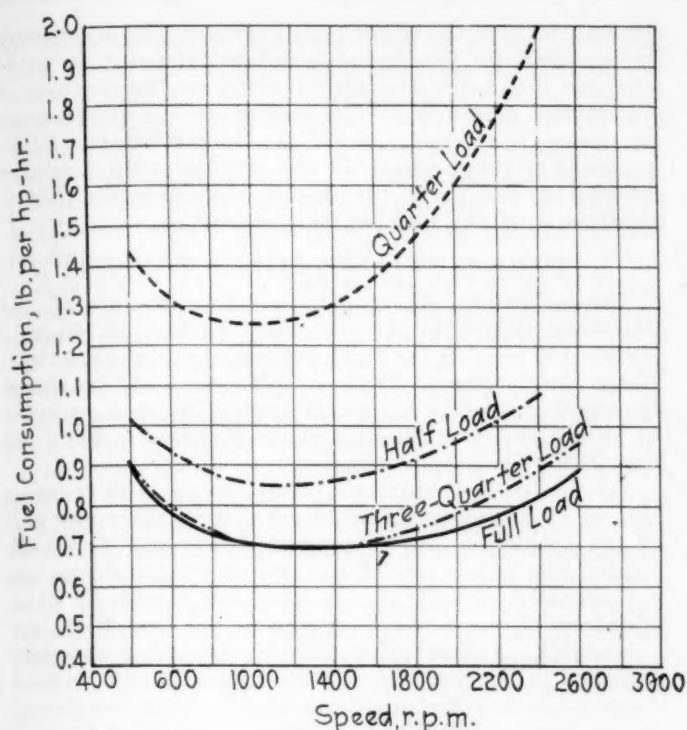


FIG. 1—FUEL CONSUMPTION OF AN AVERAGE AUTOMOBILE ENGINE AT VARIOUS LOADS AND ENGINE-SPEEDS

Consumption is Least at Full Load and Increases Rapidly as the Load is Decreased. The Average Car Has Power Greatly in Excess of That Required To Drive It at Constant Speed on Level Roads and It is Necessary To Throttle the Engine and Run Under Partial Load

in temperature resulting from compression of the mixture.

#### MORE WORK WITH LESS NOISE

Heat losses in the water-jacket are decreased because a greater quantity of fuel per charge is burned. The relation of the surface area of the combustion-chamber to its volume remains constant for every charge irrespective of the quantity of fuel used. Therefore, the cooling losses in the water-jacket with respect to the wall surfaces of the combustion-chamber are large compared with the quantity of a small charge and are correspondingly smaller with a larger charge. While the losses due to cooling decrease with the larger charge, the amount of mechanical work done by the heat units of the charge increases. The advantages of the larger charges are so great that they surpass by far the slight losses due to the unfavorable condition of expansion.

Owing to the increased quantity of mixture per charge, which raises the expansion curve in the pressure-volume diagram, it is possible to open the exhaust-valves later, thus utilizing more fully the amount of work available during the expansion stroke. The time of opening the exhaust-valves in present engines is governed by the back-pressure developed in the manifold and muffler, which pressure must be overcome to force the gases into the atmosphere. Since the pressure in the cylinder at the end of the expansion stroke is higher in the supercharged engine, the exhaust-valves may be opened later.

An engine can be made quieter by providing a more gradual lift of the valves. The inlet-valve cams in the unsupercharged engine are of a shape to provide the greatest possible opening of the valve in a comparatively short time. This action can be obtained only at the expense of quietness in the valve mechanism. In the supercharged engine, the mixture is forced into the cylinder irrespective of the rate of valve opening, hence the lift of the valve may be more gradual. Moreover, smaller

valves that are lighter and less likely to overheat than the larger ones can be used. As a consequence, the total weight of the valve mechanism can be reduced and lighter valve-springs used, thereby decreasing the wear of the parts as well as the noise of operation.

#### FUEL CONSUMPTION IS DECREASED

An engine of smaller piston-displacement can be used, as the supercharger is the means of providing the excess power needed for acceleration and hill-climbing. The most important of the many advantages derived from the use of a smaller engine is the reduced fuel-consumption. Since the power that can be developed by the average modern automobile engine is greatly in excess of the power required to drive the car along the level road at constant speed, it is necessary to throttle the engine or run under part load. The rate of fuel consumption changes very rapidly, however, with throttled conditions. A lower fuel-consumption is greatly to be desired in view of the present trend toward economy and the conservation of fuel.

The decrease in fuel consumption due to the use of a smaller engine is shown by Figs. 1 and 2. Curves in Fig. 1 show the relation between fuel consumption in pounds per horsepower-hour and speed of the engine at various loads. The most economical rates of fuel consumption are obtained under full and three-quarter-load conditions, and the consumption increases rapidly as the load decreases.

In Fig. 2 the upper curve shows the horsepower of an American engine of average size and the lower curve shows the horsepower required to propel the car on level ground. The latter curve represents the total horse-

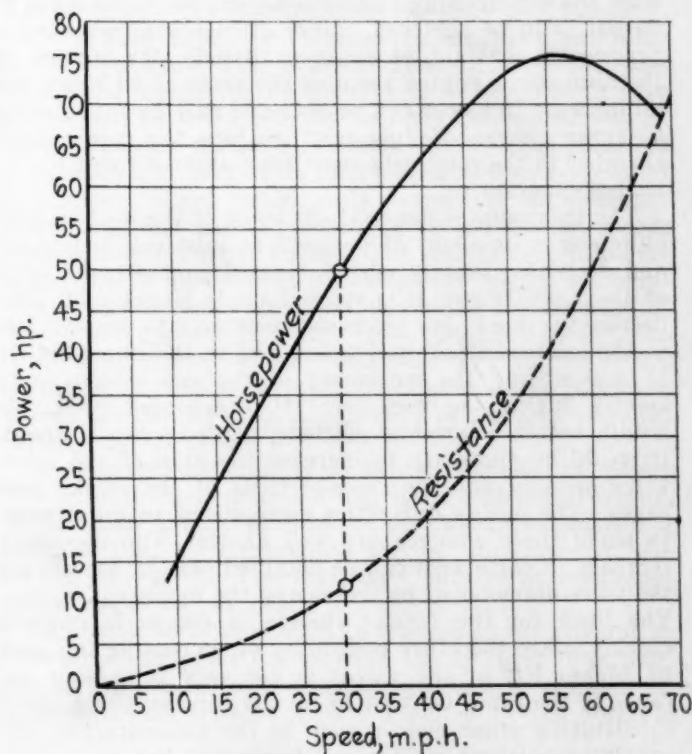


FIG. 2—RELATION OF ENGINE HORSEPOWER AND POWER REQUIRED TO PROPEL A CAR ON A LEVEL ROAD

The Resistance Curve Below Indicates the Power Required To Overcome Resistance Due To Wind and Road Conditions for an Average American Car at Different Speeds at Full Load. At 30 M.P.H. the Engine Can Develop 50 Hp., but Only 12 Hp., or One-Quarter Load Is 1.34 Lb. per Hp-Hr., Whereas at Full Load or on a Level Road. Fuel Consumption at That Speed and One-Quarter Load Is 1.34 Lb. per Hp-Hr., Whereas at Full Load or Three-Quarter Load the Engine Develops 12 Hp. on a Consumption of 0.70 Lb. per Hp-Hr., or 48 Per Cent Less

power required to overcome the total resistance due to wind and road conditions. Taking as a specific example the conditions existing at 30 m.p.h., it will be noted that the engine develops 50 hp., but the power required to drive the car at constant speed is only 12 hp., or approximately one-quarter of the full power. The fuel consumption at that speed and one-quarter load is 1.34 lb. per hp-hr., as indicated in Fig. 1. For full or three-quarter-load conditions, the consumption is only 0.70 lb. per hp-hr., or 48 per cent less. Corresponding figures are different, of course, with different engines and different speeds, but this example serves to show the gain that would be possible if a smaller engine that would drive the car at that speed under a higher load were installed in the car.

It can be shown in a similar way that the mechanical efficiency of the engine decreases with part load. In the example given, the mechanical efficiency was 85 per cent at full load and 57 per cent at one-quarter load, therefore the advantage of using a smaller engine operating under nearly full-load conditions is evident.

Another reason exists in Europe for the preference for a small engine. The Government tax on the car is considerably less. An engine that develops the horsepower curve shown in Fig. 2 is taxed \$150 per year in England and \$200 in Germany.

#### PROBLEM OF THE AUTOMOBILE SUPERCHARGER

The problem involved in designing a supercharger for the automobile differs from that involved in the first supercharger developed for airplane engines. The airplane supercharger is used merely to maintain constant power-output of the engine at different altitudes, whereas with the supercharged automobile engine an increase in output is to be achieved. Since atmospheric pressure is practically constant at a given altitude, the suction of the automobile engine remains the same at all times and an increase in power can be obtained only by introducing a larger charge of fuel mixture into the combustion-chamber in the relatively short time allotted for it by the timing diagram.

The maximum volumetric efficiency of the modern gasoline engine is about 85 per cent at relatively low speed and decreases rapidly with increased engine-speed until at about 6000 r.p.m. it is approximately 55 per cent. This decrease is due to the increased resistance to the gas-flow in the inlet-manifold and valves and to the impossibility of accelerating the movement of the gas column sufficiently during the very short time accorded to it. To obtain better volumetric efficiency with increased speed, it would be necessary to increase the area of the inlet-valve opening and the cross-sections of the intake passages. The design difficulties encountered in an attempt to make these changes are well known. The necessary increase in valve area can be obtained only by increasing the valve diameter or by increasing the number of valves. The limit for the former change in design is reached quickly, since the other possibility of increasing the area by higher lift of the valves is not very promising because of the rapid increase of inertia forces. The need of substituting other means, such as the supercharger, for supplying a larger charge and increasing the volumetric efficiency is therefore beyond question.

Weight of the intake charge can be increased by increasing the intake pressure, which will of course increase the final pressure if the compression-ratio is not changed. If, however, the final pressure is already as high as is desired, an increase in power can be obtained by lowering the compression-ratio and supercharging

enough to give the same final pressure. An appreciable power increase can be obtained by applying a supercharger just large enough to overcome the decrease in volumetric efficiency of the engine as the engine-speed increases. The supercharger, by increasing the intake pressure slightly, would fill the cylinder with a greater weight of charge at the higher engine-speeds than is possible with the unsupercharged engine.

#### MERCEDES 24-100-HP. SUPERCHARGED CAR

The principal dimensions of the engine of the 24-100-hp. Mercedes car are: bore, 80 mm. (3.150 in.); stroke, 130 mm. (5.118 in.); number of cylinders, 6; total piston displacement, 3920 cc. (239 cu. in.); maximum horsepower developed, 100. Weight of the car, exclusive of passengers, is 2800 lb., and the tire size is 895 x 135 mm. (35 x 5 in., approximately).

The engine is of fairly orthodox design, with cylinders cast in an aluminum block integral with the upper part of the crankcase and fitted with liners and detachable heads. The valves are of the inverted vertical-type and are operated directly by an overhead camshaft, which is driven by silent worm-gearing at the rear of the cylinder-block. A patented automatic carbureter, especially designed in conjunction with the supercharger, is used. A specially designed auxiliary fuel-tank on the dash is drawn upon automatically when the supercharger is in use. The supercharger, which is of the Roots blower type, forms part of the engine design and is located forward of the cylinder-block. It becomes operative when the accelerator pedal is depressed past the full-open throttle position. This movement of the accelerator brings into operation a multiple-disc clutch that engages a set of bevel-gears and automatically connects the supercharger and closes the normal intake of the carbureter. Published descriptions of the operation of the supercharger have appeared so often that it seems unnecessary to go into it again.

An increase of power of about 40 or 50 per cent can be obtained with the supercharger, as can be seen from the acceleration obtained with and without it in action. The normal cruising speed of the Mercedes car without the supercharger is in the region of 50 or 60 m.p.h. By the addition of the supercharger, a speed of approximately 90 m.p.h. is obtainable. Acceleration tests conducted with this car have shown the following results: On high gear the car accelerated from 10 to 30 m.p.h. in 10 sec. with the supercharger, while without the supercharger the time required was 13 sec. Acceleration time on intermediate gear for the same range in speed was 4.0 sec. with the supercharger and 6.8 sec. without it. Tests for acceleration from 10 to 40 m.p.h. on intermediate gear gave the time as 6.2 sec. with supercharger and 13.8 sec. without.

It is interesting to compare these last figures with those obtained in the tests from 10 to 30 m.p.h. With the supercharger the car accelerated faster from 10 to 40 m.p.h. than it did from 10 to 30 m.p.h. without supercharger. It was comparatively slow in running up to 40 m.p.h. on intermediate gear, and it seemed as if 40 m.p.h. was about the limit of speed the car could attain on intermediate gear without the supercharger.

#### PERFORMANCE WITH AND WITHOUT SUPERCHARGER

Performance of the 24-100-hp. Mercedes engine with and without supercharger is shown in Fig. 3. The two principal curves are A and B, which show the horsepower developed by the car respectively without and with the supercharger in operation. Another interesting curve is

C, which shows the power required to propel the car at constant speed on level road, and the significance of which already has been explained. It is evident that the intersection of curve C with the horsepower curve B of the engine would show the maximum speed the car can attain. Its intersection with the curve of the supercharged engine occurs at 87 m.p.h., which is approximately the highest speed attained with the car in tests conducted at Brooklands.

It is well known that there are two types of horsepower curve, with well-defined characteristics. The high-speed-engine curve is approximately a straight line at the lower speeds and is inclined at an angle to the abscissa. At higher engine-speeds the curve gradually approaches the horizontal but is still rising at the maximum speed of the car without actually reaching its peak within the driving range. The low-speed-engine power-curve rises more rapidly at the lower speeds, or shows a higher torque than the high-speed-engine curve and is concave toward the abscissa. It reaches its peak at moderate speeds and falls-off rapidly. Beneath the Mercedes power curves in Fig. 3 has been drawn, as a broken line, the power curve of a high-speed engine of the same displacement as the Mercedes 24-100-hp. engine. Data for the construction of this curve for comparison with the two Mercedes power-curves show that the Mercedes unsupercharged engine undoubtedly belongs in the low-speed class, while the supercharged engine possesses the characteristics of the high-speed engine.

The unsupercharged-Mercedes-engine curve A reaches its peak at a car-speed of about 65 m.p.h. and drops-off rapidly from there. The reason for this sudden drop evidently can be found in the fact that the Mercedes engineers realized that they could reduce the size of the manifolds and valves and valve-lifts, as well as take greater freedom with the timing diagram to obtain a more quiet engine without sacrificing performance, as the supercharger would take care of any deficiency of power whenever desired. In brief, the sudden drop in power at the higher speeds is caused by the restricted manifold and valve areas. The curve of the unsupercharged Mercedes has been constructed for a compression-ratio of 5.4 to 1.0, which is the actual ratio that exists in the car. Assuming that the inlet passages had not been restricted, it is evident that the curve would have taken the shape indicated by curve D.

#### INCREASE IN POWER OBTAINED

Analyzing the two power curves of the Mercedes car, with and without supercharger, A and B, with the object of establishing some relation between them, Table 1 shows the horsepower developed in each case and, in the last column, the percentage of increase in power obtained by the use of the supercharger. From this we find

TABLE 1—HORSEPOWER DEVELOPED BY 24-100-HP. MERCEDES ENGINE AT DIFFERENT ENGINE-SPEEDS, WITHOUT AND WITH SUPERCHARGER, AND PERCENTAGE OF INCREASE DUE TO USE OF SUPERCHARGER

Engine Speed, R.P.M.	Power Developed Without Super- charger, Hp.	Power Developed With Super- charger, Hp.	Increase in Power, Per Cent
1,800	59.25	69.75	17.70
2,000	64.50	79.25	22.87
2,200	67.50	86.75	28.52
2,400	69.75	93.75	34.40
2,600	67.50	99.75	47.70
2,800	64.75	102.25	57.90
3,000	58.75	102.75	74.90
3,200	45.25	98.50	117.60
3,300	30.50	93.00	204.90

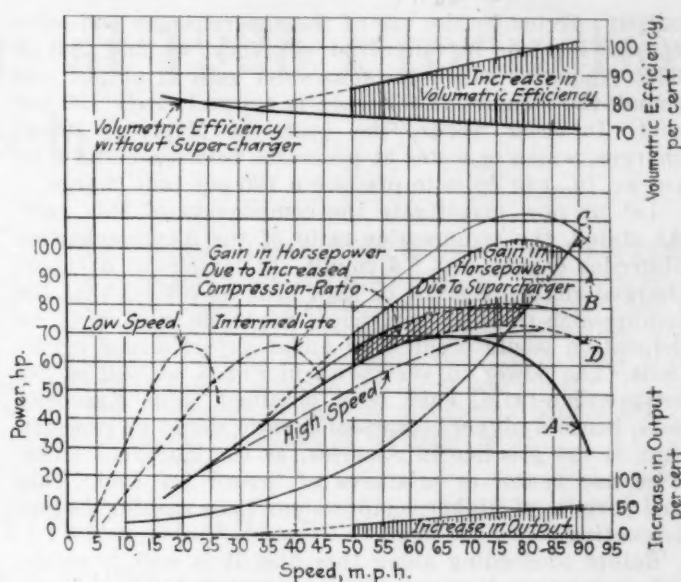


FIG. 3—COMPARISON OF PERFORMANCE OF MERCEDES 24-100-HP. ENGINE WITH AND WITHOUT SUPERCHARGER

The Shaded Area in the Central Figure Shows the Total Gain in Power Due to Use of the Supercharger, While the Cross-Hatched Area Shows the Gain Due to the Higher Compression-Ratio. Intersection of the Curve C of Power Required To Propel the Car at Constant Speed with the Horsepower Curves A and B Indicates the Maximum Possible Speed of the Car, Which Is 75 M.P.H. without and 87 M.P.H. with Supercharger. The Minor Broken-Line Curve Below the Mercedes Power-Curves Is the Power Curve of a High-Speed Engine of the Same Piston Displacement as the Mercedes and Shows That the Unsupercharged Mercedes Belongs in the Low-Speed-Engine Class and the Supercharged Engine in the High-Speed Class. The Drawing at the Top Represents Increase in Volumetric Efficiency Due to Supercharging and That at the Bottom the Increase in Engine Power-Output, Both in Percentage

that at 1800 r.p.m. the increase was only 17.7 per cent, while at 3300 r.p.m. the increase reached the great value of 204.9 per cent. This is evidently an impossibility, and the results undoubtedly will have to be modified to give a true picture of the relation between the two curves.

As has been stated, restriction in the inlet-manifold and valves has very little effect upon the power output of a supercharged engine with respect to the different speeds but has a great influence at the higher speeds of the unsupercharged engine. The sudden drop in horsepower in the unsupercharged Mercedes engine undoubtedly is due to this restriction, hence the modification of this power curve would have to be along this line. The horsepower curve of the unsupercharged engine would appear as in D if no restrictions existed in the passages. The total gain in output would then be the area included between curves D and B.

If we now determine the relation between the power curves of the supercharged and unsupercharged engine, we find that the gain in output follows approximately a straight line, as represented by the diagram at the bottom of Fig. 3. The maximum gain is at maximum speed and is 54 per cent.

Extensive tests conducted in Europe in an attempt to determine some relation between the increase in output,  $dL$ , and the increase in charge expressed in per cent of volumetric efficiency,  $de_v$ , have resulted in the formula

$$dL = 1.8 de_v \quad (2)$$

or, expressed in English, an 18-per cent increase in power is obtained with a 10-per cent increase of charge.

#### VOLUMETRIC EFFICIENCY INCREASED TO 100 PER CENT

At the top of Fig. 3 is a curve representing the volumetric efficiency of an engine whose power curve has been plotted in curve D. If we now apply formula (2) to the curve at the bottom of Fig. 3 showing the gain in

output effected by the use of the supercharger and solve for the increase in volumetric efficiency, we find that at 3300 r.p.m., at which the maximum gain in output was found, the volumetric efficiency is approximately 100 per cent. In other words, the best the Mercedes supercharger, which operates at pressures between 5 and 6 lb. per sq. in., can do is to produce a 100-per cent charge.

Let us now investigate the components of this gain. As stated, the compression-ratio of the unsupercharged Mercedes engine was 5.4 to 1.0. In laying-out a supercharged engine, it must be kept in mind always that the compression-ratio at all times would be such that no detonation would occur even under supercharged conditions. The power curves shown in Fig. 3, as well as the compression-ratio, have been obtained from European data, hence a higher compression-ratio would be expected than is the practice in America, as the European countries use benzol or mixtures of benzol for fuel. This fuel permits of higher compressions than gasoline before detonating.

Before proceeding along this line, it is well to establish a relation between the compression-ratio and the volumetric efficiency. The following formulas are well known:

$$\epsilon = (V_1 - V_c) / V_c \quad (3)$$

where

$e_v$  = volumetric efficiency

$\epsilon$  = compression-ratio

$V$  = theoretical piston displacement, or volume of cylinder

$V_1$  = actual piston displacement

$V_c$  = volume of combustion-chamber

or

$$\epsilon - 1 = V_1 / V_c \quad (4)$$

and

$$e_v = V_1 / V \quad (5)$$

so that

$$V_1 = V e_v \quad (6)$$

By substitution we obtain, at two different compression-ratios, the relation

$$(\epsilon_1 - 1) / (\epsilon_2 - 1) = [(V e_{v1}) / V_c] / [(V e_{v2}) / V_c] = e_{v1} / e_{v2} \quad (7)$$

Substituting for the Mercedes unsupercharged engine at 3000 r.p.m. the value for the compression-ratio and volumetric efficiency  $\epsilon_1 = 5.41$  to 1.00 and  $e_v = 70$  per cent, and assuming that at the same speed the supercharged engine has a volumetric efficiency of 100 per cent, we find that the compression-ratio  $\epsilon_2$  of the supercharged engine increased to  $(5.4 - 1) / (\epsilon_2 - 1) = 70/100$ , or  $\epsilon_2 = 7.3$  to 1. In other words, the compression-ratio at different speeds of the supercharged engine increases with increased speed and this is partly the cause of the increased power-output. At the same time the thermal efficiency increases according to the formula

$$e_{th} = 1 - [1/\epsilon^{n-1}] \quad (8)$$

where

$e_{th}$  = thermal efficiency

$\epsilon$  = compression-ratio

$n$  = coefficient for adiabatic expansion

Since the factor  $\epsilon$  is in the denominator, the thermal efficiency also rises and thereby produces a higher output of the engine that increases as the speed increases. By substituting the same value for the compression-ratios for both engines, we obtain for the supercharged engines an increase in thermal efficiency of 12.5 per cent. An increase in thermal efficiency necessarily produces an increase in power output. The remainder of the increase in power is due, of course, to the greater number of heat units contained in the larger charge.

If this engine is to be run with gasoline, the initial

compression-ratio will need to be lower to avoid detonation at the highest speed while operating with the supercharger.

#### POWER REQUIRED TO DRIVE SUPERCHARGER

Let us now determine how much power is required to drive the supercharger. The piston displacement of this engine is, as stated, 239 cu. in., while the speed at which the supercharged engine delivers maximum power is 3000 r.p.m. Since the cylinder will be filled only during the intake stroke, or every other revolution of the crankshaft, the air displacement will be  $1500 \times 239 / 1728 = 208$  cu. ft. per min. The volumetric efficiency of the unsupercharged engine at this speed was 70 per cent. To increase the volumetric efficiency to 100 per cent, it will therefore be necessary to draw air from a source where the pressure is  $14.7 \div 0.7 = 21.0$  lb. per sq. in.

To determine the work done in compressing the charge adiabatically, the following formula may be applied:

$$W = (144/33,000) p_1 V_1 [n/(n-1)] \times [(p_2/p_1)^{(n-1)/n} - 1] (1/e_m \text{ and } v) \quad (9)$$

where

$e_m$  and  $v$  = mechanical and volumetric efficiency, assumed as 0.5

$n = 1.4$  = coefficient of expansion

$p_1$  and  $p_2$  = pressure in pounds per square inch

$V_1$  = volume of air in cubic feet

$W$  = work done, in horsepower

Substituting values for the Mercedes car in this formula, we get

$$W = (144/33,000) \times 14.7 \times 208.0 \times [1.4/(1.4-1.0)] \times [(21.0/14.7)^{(1.4-1)/1.4} - 1] \times (1.0/0.5) \quad (10)$$

Therefore

$$W = 10.1 \text{ hp.}$$

#### POWER FROM FULL CHARGE OF FUEL

Let us now determine how much power can be obtained from fuel with this engine having a full charge. Let the fuel used be able to furnish 19,000 B.t.u. per lb. when exploded in the engine. Assuming the mixture-ratio of air to fuel to be 15 to 1, then from every pound of fuel we shall obtain  $15 + 1 = 16$  lb. of gas-air mixture. One pound of the mixture will then be able to furnish  $19,000/16 = 1190$  B.t.u. at 62 deg. Fahr. and 29.92 in. of mercury pressure. One liter (61 cu. in.) weighs 0.00286 lb. The energy  $E$  given up by 1 liter, expressed in foot-pounds, and considering that 42.4 B.t.u. are equal to 1 hp., will be

$$E = (0.00286 \times 1190) / 42.4 = 0.08027 \text{ hp.} \quad (11)$$

If the thermal efficiency be taken as 30 per cent, the energy transformed into work for 1 liter will be  $0.08027 \times 0.3 = 0.02481$  hp., assuming that the ratio of useful diagram to the theoretical diagram is 90 per cent and the mechanical efficiency is 80 per cent. Then the effective work produced by the gas per liter is  $0.02481 \times 0.9 \times 0.8 = 0.01786$  hp., and at 3000 r.p.m. the power produced for the engine with a displacement of 239 cu. in. will be  $0.01786 \times (239/61) \times (3000/2) = 105$  hp.

From Table 1 it is seen that the actual horsepower at 3000 r.p.m. was approximately 103 hp., hence the charge in the cylinder due to the use of the supercharger must have been in the neighborhood of 100 per cent.

#### CANNOT DISPENSE WITH CHANGE-SPEED GEARS

Some authorities are of the opinion that the transmission, or gearbox, can be dispensed with if a supercharger is installed, since the additional torque that is

(Concluded on p. 523)

# Discussion of Papers at 1925 Production Meeting

THE discussion following the presentation of two of the papers at the Production Meeting of the Society held at Cleveland last September is printed herewith. The authors were afforded an opportunity to submit written replies to points made in the discussion of their papers and the various discussers were provided with an edited transcript of their remarks for approval before publication.

For the convenience of the members, brief abstracts of the papers precede the discussion in each case so that those who desire to gather some knowledge of the subjects covered without referring to the complete text as originally printed in the November, 1925, issue of THE JOURNAL can do so with the minimum effort.

The discussion of the two remaining papers will, it is expected, be published in an early issue.

## MAKING MACHINE-TOOLS SAFE

BY R. F. THALNER<sup>1</sup>

### ABSTRACT

EVOLVING gradually since the time when opinion prevailed that accidents are unpreventable, modern safety methods have come into being and successfully organized effort concentrated on their application in industry has accomplished an amazingly effective system of accident prevention. In the automotive industry, effort focused on preventive measures looking toward the elimination or reduction of casualties and fatalities has resulted in greatly increased conservation of life and property; but, as new conditions and new demands continually appear, it is evident that new methods, new means and new modifications must be continually in process and that putting these forces into production requires concentrated scientific study, forethought and executive ability. Therefore, the author not only outlines previous and present practice but states the governing factors of accident-prevention progress and suggests possibilities of improvement of methods and the means for applying them, referring specifically to machine-tools.

Forethought exercised in the design of tools to make them safe as well as suited to the work is the best method, and redesign is practised when hazards become apparent after a tool is put into operation. If redesigning a tool does not make it safe to operate, the next best method is to guard it.

Among the fundamental factors governing the safe operation of tools are the following rules. Men who operate vertical drilling-machines never should wear gloves or long sleeves. Milling-cutter chips should be brushed aside only with a brush or with a stick, and holding fixtures should make it unnecessary for the workman to expose his hands unduly to the cutter. Belts and gears ought always to be covered to prevent the entanglement of workmen. Chips and long shavings from lathe tools can largely be eliminated by proper grinding of the tool, and flying particles from high-speed brass-turning operations can be controlled safely by sheet-metal guards.

Grinding-wheels and woodworking tools necessitate careful guarding, the various means, including the use of goggles, being mentioned. Hand operations and the use of shock-tools such as hammers, chisels, stamps, drills, drift-pins, punches and plugging-tools, are also discussed from the standpoint of safety. Emphasis is centered on the statements that most accidents are caused, they do not simply "happen," and that tools which cause accidents can be made safe.

### THE DISCUSSION

R. F. THALNER:—Supplementing my paper, the place to start the elimination of accidents in industry is in the design of the jig or fixture and, if that were given more attention, many accidents that now occur in shops would not happen. More men have been injured while brushing chips away from fixtures with their fingers and gloved hands than have been injured when using a stick or a brush for that purpose. Drill-breaking seems not to be a dangerous occupation but, when breaking steel, especially high-speed steel, particles are certain to fly-off. A jig devised by the Ford Motor Co. consists of a  $\frac{3}{4}$ -in. plate with holes in its side and a box around it; this jig eliminates danger to the workman. The high-speed end of the drill is inserted in a hole in the plate, a long bar that will accommodate a drill-shank end is placed over the drill-shank and it is thus broken-off.

A strong argument was made that if circular heads were installed on the jointing machines in our wood-working shop the force could not turn out the required production; but one was installed and, as it proved satisfactory, all the machines now have circular heads. In addition to being safe, they effect a saving.

After we had adopted the bull's-eye hammer-head as standard, a man came to work in the plant who had a hammer of his own, having a criss-crossed corrugated-face somewhat like that of a hatchet-head. Before he began work, a new handle was put into the hammer so that it would be in good condition. Within a short time the man was in our hospital, having lost the sight of one eye. Inspection of the hammer showed that one of the little ridges near the edge of the face had broken off, permitting a nail to glance-off and strike the man's eye.

A safety device in the form of a bar is used to lock the open end of the rail on the monorail conveyor-system. A device installed by the manufacturer did not prove to be a safety device for one of our operators. He ran into it and, thinking he had hit the end of the other beam, he backed up and ran into it again. His car dropped and he lost an arm. So, a  $1\frac{1}{2}$ -in. bar was mounted at the switch-point, which automatically pulls out of the web of the beam to be used and closes both of the open ends. Cars that have hit this bar have never gone through.

Our efficiency department made a test with some of

<sup>1</sup> Safety director, Buick Motor Co., Flint, Mich.

the shock-tools that were reground with a curved edge instead of a straight-chamfered edge and drove 4300 plugs with a tool having a rounded head; but, with a tool having a straight-chamfered head, only 300 plugs were driven before the tool had to be re-dressed. Each plug is struck four or five blows. This illustrates the increased service and effectiveness of the rounded head, in addition to its greater safety.

#### FACTORY INSPECTION INADEQUATE

**CHAIRMAN JOHN YOUNGER:**—One way to prevent accidents is to place guards on the machines, as Mr. Thalner has explained; another very important way is to train the men to look out for their own safety.

**E. F. DU BRUL:**—The difficulty that confronts us all in the matter of guards is to secure uniform safety codes in the different States. A guard that is required in one State is positively forbidden in some other State. We have asked the casualty companies for figures showing how many accidents were caused at the point of the tool, but the companies that insure the manufacturer could supply no statistics showing at what part of the machine the accidents occurred. Belts on a machine can be guarded, but accidents at the point of the tool cannot be prevented unless there is a guard at the point.

Safety first is not only an humanitarian movement but it is dollar-and-cents economy. It is difficult to induce the men to use safety devices after they are installed; a few people in the world do the thinking for the remainder. It is surprising that it has taken so long for the safety movement to get a start, and it is remarkable that the movement has not made more progress than is observable.

A very practical thing we must do is to obtain uniform safety codes that are based on facts and experience and not on the ideas of political appointees who are acting as inspectors. Factory inspectors should be taken out of politics. Employers should be more interested than they are in the kind of inspection that is given to factories. They have neglected their own interests by letting outside interests make the inspection. They do not realize how much the neglect is costing them in money, and how much it costs their men in misery because of the deficiencies of the present safety codes and regulations.

#### MAKING POWER HAMMERS SAFE

**W. G. CAREINS:**—What has the Buick Company done to make steam hammers and drop-forging hammers safer?

**MR. THALNER:**—Referring to board hammers in particular, we have no safety device on them at present other than the clamps on the board, but we do place a screen guard over the operator so that the board cannot hit him. That protects every operator in the press room, but we neglected to prevent that accident from happening to the ordinary passer-by in the shop. That is our next job. There is a very serious hazard in the use of board hammers. One safety device for a board hammer is to place a cap over it to enclose the full stroke of the board, and I believe that the Dominion Forge & Stamping Co., Walkerville, Canada, guards its board hammers in that way. The use of specially constructed boards also reduces the hazard to the minimum.

On the upper end of the piston in our steam hammers is a so-called "expansion pot" that prevents the breaking

of the steam cylinder. It was designed by the master mechanic in our drop-forging plant. It is a simple device, but it saves thousands of dollars by preventing cracked cylinders. We have not enforced strictly the rule that men working on machines should use goggles, but a surprisingly large number of the men who work on the hammers do wear goggles.

**B. B. BACHMAN:**—Mr. Thalner has covered the subject of safety in the field of production work, but another field exists in which it is more difficult to protect the workers and in which we may have to rely upon the proper training of the men. I refer to the work that is done in the engineering and the experimental departments where the character of the work is widely varied and is not done on specialized machines but on all kinds of machine and, very frequently, on improvised apparatus. The hazards are very great. Some hook-ups are all right for the purpose for which they are intended, but they are positively dangerous. By a gradual process of education, an organization can be taught to avoid such dangers.

Some phases of safety work are entirely beyond the scope of codes and depend largely upon the individual judgment of the man who has them in charge. Meetings of this character bring to us, in a new light and from a fresh viewpoint details that, because of their every-day occurrence and our too great familiarity with them, become so commonplace that we do not think of them.

#### INDUSTRIAL FATALITIES OUTNUMBER WAR KILLED

**EUGENE BOUTON:**—Will Mr. Thalner explain more fully his statement regarding the 85,000 accidents in this Country last year? Did the 23,000 occur in the metal-working industry exclusive of the steel mills?

**MR. THALNER:**—That is as exact an estimate as can be obtained. The 23,000 includes all industries in this Country.

**CHAIRMAN YOUNGER:**—I once heard the statement that more men are crippled in the United States by industrial accidents than were killed in the Canadian forces during the world war.

**MR. THALNER:**—I think the number of persons killed in accidental ways is greater than the number of American soldiers killed in war.

#### BETTER STATE FACTORY INSPECTORS NEEDED

**RUSSELL HOOPES:**—In Pennsylvania, the factory inspectors request the guarding of belts. In other States, do they insist upon guarding things that are more dangerous?

**MR. THALNER:**—The ordinary factory inspector can see only the belt guard. Statistics show that our plant has not had an accident due to a belt in more than 1 year. We show the inspectors an analytical chart depicting where our accidents occur and say to them: "We have not had an accident due to belts, and yet you want us to install a number of belt guards." The statistics cause the inspectors to think. I do not mean that belts should not be guarded, for many belts are dangerous; but I do not believe that every little belt should have a guard.

A factory inspector recently appointed by a new administration once came into our office and acknowledged that he knew nothing about his job. We admired his frankness and took him through the plant, educating him in safety as he should be educated, so far as possible. We told him that we saw no sense in guarding every little belt but that we made periodic inspections of milling machines, milling cutters and other machines that the State inspectors never notice. This is illustrative of a

<sup>2</sup> M.S.A.E.—Publisher and editor, *Automotive Abstracts*; professor of industrial engineering, Ohio State University, Columbus, Ohio.

<sup>3</sup> General manager, National Machine Tool Builders Association, Cincinnati.

<sup>4</sup> M.S.A.E.—Engineer, Autocar Co., Ardmore, Pa.

situation about which we are much concerned. We spend time in studying accidents and their causes, and to have a State inspector come in who never has given a moment's thought to the subject is not right. The sooner our State inspectors are men who know their jobs, the better off we shall be. For the State of Michigan, I wish to say that Mr. Thrall, supervisor of inspectors, is doing everything in his power to employ experienced men.

CHAIRMAN YOUNGER:—Do you know of any guard that is effective for perforating and blanking dies?

MR. THALNER:—That depends upon the size of the job. If the work is performed on a large piece of sheet metal

I know of no satisfactory guard. The best method would be to feed the stock by using tongs and take it out with tongs. For small stock, we use chute feeds.

A MEMBER:—In the majority of blanking and perforating operations, the practice is to push the stock right through the machine and there is danger that the workman will put his fingers under the die. For operations of that kind, where the stock is say 2 or 3 in. wide, a chute is built; the workman feeds the stock through it and the blanks drop off at the other end. The die can be enclosed on the other end and the last piece of stock can be pushed through by the next piece that is started.

## SOME ASPECTS OF AIRPLANE INSPECTION

BY J. J. FEELEY\*

### ABSTRACT

**F**OLLOWING a description of airplane structure, the author discusses structural requirements and outlines the main features of properly coordinating the engineering and the manufacturing activities. He says that each of the three subdivisions of airplane design has its own series of calculations, these being related to predictions of performance before the machine is built, to stability determinations and to the design of a self-contained structure of sufficient strength to withstand any stresses developed in flight or in landing. He states also that no inspection is worth the name or the money spent on it that does not include constructive work and a knowledge at all times that the intentions of the designers are being carried out in detail so that the safety of the craft is assured.

Materials used in aircraft should be light and easily workable and should possess the desired physical and chemical properties; they must have the specified cross-section and be free from defects. The methods of sampling, testing and inspecting materials are stated.

Wood structure and the kinds of wood most suitable are described, together with statements and illustrations regarding the most common defects and how they are detected, and similar explanations are made concerning the metals used.

The methods applying to fabrication, to assembling and to deterioration prevention are stated, as well as those of "doping" and finishing, and the inspection procedure for each is outlined, inclusive of that for the final assembly.

### THE DISCUSSION

QUESTION:—Is the wing structure always riveted?

J. J. FEELEY:—The wing that was shown on the screen is of all-riveted construction. Welding of the high-strength aluminum-alloys into structures of this kind is not desirable if the full strength of the material is to be retained. Welding is being done to a great extent on steel structures, with success.

ANCEL ST. JOHN<sup>6</sup>:—Is the eccentricity of the gage of tubes a common occurrence?

MR. FEELEY:—It is fairly common. The eccentricity referred to is due to bad drawing-conditions at the tube mill. We have found say a dozen such cases. When an airplane is being built, safety must be considered all through its structure and eccentric tubing must be eliminated. Every member must be kept true to size and weight.

QUESTION:—After it is dried, why is the lumber stored 2 weeks before it is used in airplane construction?

MR. FEELEY:—Wood just out of the kiln usually is slightly case-hardened. If it is allowed to stand for about

2 weeks, it becomes balanced with the surrounding shop-conditions and allows slight internal stresses to adjust themselves.

MR. ST. JOHN:—How much loss must you allow for lumber that is rejected on account of defects such as pitch-pockets, concealed knots and the like?

MR. FEELEY:—We buy lumber according to our specifications and pay an extra price for it. Of the raw lumber that we receive, probably not more than 10 per cent is rejected when first inspected as received. As it proceeds through the factory, about 10 per cent of the remaining lumber is rejected.

MR. ST. JOHN:—Do not unseen defects cause a considerable amount of wasted labor?

MR. FEELEY:—Yes.

MR. ST. JOHN:—Cannot the inspection of wood be made on practically a 100-per cent basis for such important service as this, aided by the X-ray, considering the high prices that must be paid for lumber.

MR. FEELEY:—Some defects can be located more definitely with the aid of the X-ray, although the more serious defects in healthy timber might not be discovered, such as spiral grain, which represents a condition rather than an object. I believe X-ray inspection might be practicable in large operations, but its value on small-scale operation seems doubtful because many of the imperfect long pieces have the imperfections cut from them and the remaining stock is used for smaller details and assemblies.

## PRACTICAL APPLICATIONS OF SUPERCHARGERS

(Concluded from p. 520)

obtained at present by the gear reductions can be supplied by the supercharger. It is possible that at some future time a supercharger may be developed that will be able to do this. None of the superchargers so far developed, however, is able to fulfill the conditions imposed upon the gearbox. The present Mercedes supercharger especially does not adapt itself to this task. It is characteristic of the automobile engine that the torque fluctuations vary as the square of the speed variations. This is true especially at the low speeds. The increase in power due to the use of the supercharger at these speeds, however, varies as a straight line. On the other hand, the Mercedes supercharger does not start to act at low speeds. Some claim that its initial operation is at 10 m.p.h., others that it is at 30 m.p.h. Therefore, no increase in engine torque at the lower speeds can be expected.

\* Chief inspector, Glenn L. Martin Co., Cleveland.

<sup>6</sup> Consulting physicist, New York City.

# Applicants Qualified

The following applicants have qualified for admission to the Society between March 10 and April 10, 1926. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member.

ATKINSON, HARLAND B. (J) draftsman, Paige Detroit Motor Car Co., *Detroit*; (mail) 12051 North Martindale Street.

BUCK, ARTHUR V. (A) superintendent of repairs, Hahn Motor Truck Co., *Hamburg, Pa.*; (mail) 130 North Fifth Street.

BUHLMANN, KARL (F M) engineering adviser to the Post Office Department, *München, Germany*; (mail) Prinzregentenstrasse 52/11R.

CARTER, FLOYD B. (M) mechanical engineer, Fate-Root-Heath Co., *Plymouth, Ohio*.

CLARK, NORMAN B. (J) assistant chief draftsman, Standard Motor Truck Co., *Detroit*; (mail) 3684 Trumbull Avenue.

COLEMAN, HENRY B. (A) secretary, assistant treasurer and sales manager, Hoopes Bros. & Darlington, Inc., *West Chester, Pa.*; (mail) 509 South High Street.

CONSTANTINE, ARTHUR R. (M) development engineer, Harley-Davidson Motor Co., *Milwaukee*; (mail) 924 50th Street.

COOK, WILLIAM P. (J) laboratory assistant, White Motor Co., *Cleveland*; (mail) 1378 Beach Avenue, *Lakewood, Ohio*.

FLANAGAN, JAMES GERALD (J) designing draftsman, American Motor Body Corporation, *Philadelphia*; (mail) 3750 North Bouvier Street.

FLOCKER, ANTHONY MARIO (A) general manager and treasurer, Lancia Motors Sales Corporation, *New York City*; (mail) 7422 17th Avenue, *Brooklyn, N. Y.*

FLOWER, ALPHEUS (F M) engineer, Dodge Bros. (Britain) Ltd., *London, N. W. 10*; (mail) 10 St. Peter's Square, *Hammer-smith, London W. 6, England*.

GOODWIN, ELMER C. (A) chief engineer, department of street cleaning, City of New York, Municipal Building, *New York City*.

GUERRERA, CARMIN A. (A) special dynamics research, General Motors Corporation Research Laboratories, *Detroit*; (mail) 4933 Bevidere Avenue.

HOPKINS, ALBERT L. (M) storage-battery engineer, Prest-O-Lite Co., Inc., *Indianapolis*; (mail) Box 426.

HUGHES, VICTOR (M) research engineer, General Motors Corporation Research Laboratories, *Detroit*; (mail) 23 Oakdale Boulevard, *Pleasant Ridge, Detroit*.

HUNGERFORD, I. A. (A) distribution manager, Borden's Farm Products Co., Inc., 110 Hudson Street, *New York City*.

JONES, EDWARD T. (M) engineer, Wright Aeronautical Corporation, *Paterson, N. J.*

KOIZUKA, SHICHIBEI (F M) service manager, Yanase Automobile Co., Shibaura Factory, 2, Minam.hamacho, *Shiba, Tokio, Japan*.

KOSTER, WILLIAM A. (J) draftsman, Cruban Machine & Steel Corporation, *New York City*; (mail) 101 South Second Avenue, *Highland Park, New Brunswick, N. J.*

LARKIN, I. ENOS (A) service engineer, Philbrin Corporation, *Kennett Square, Pa.*

LEMMON, GUY (A) sales manager, Robert H. Hassler, Inc., 1535 Naomi Street, *Indianapolis*.

LOEW, CHARLES F. (M) works manager, Loew Mfg. Co., *Cleveland*; (mail) 1252 French Avenue, *Lakewood, Ohio*.

MACFARLAND, WILLIAM E. (A) chief of automotive and liberal arts palace, Sesquicentennial International Exposition, *Philadelphia*; (mail) 41 South 42nd Street, *Camden, N. J.*

MAYER, WILLIAM J. (M) assistant engineer, Edward G. Budd Mfg. Co., *Philadelphia*; (mail) 460 Lyceum Avenue, *Roxborough, Philadelphia*.

MCCLELLAND, S. S. (A) manufacturer of automobile accessories, S. S. McClelland Co., *White Plains, N. Y.*; (mail) 29 West Post Road.

MCDONELL, HORACE G. (A) service representative, Uppercu-Cadillac Corporation, 245 West 67th Street, *New York City*.

MIERAS, MERRITT A. (J) Bovey Automobile Heater Co., 3911 Prairie Avenue, *Chicago*.

OHL, C. A. (A) automotive representative, Westinghouse Air Brake Co., *Wilmerding, Pa.*; (mail) 827 Railway Exchange Building, *Chicago*.

PAGE, H. M. (A) foreman, Cleveland Tractor Co., *Cleveland*; (mail) 1745 Collamer Avenue, *East Cleveland, Ohio*.

PERRY, RAYMOND G. (A) sales manager, Gotfredson Corporation, Ltd., 242 Spadina Avenue, *Toronto, Ont., Canada*.

PIERCE, H. W. (A) Howard Pierce, Inc., 114 South Montana Street, *Butte, Mont.*

RAVIOLO, JOHN B. (M) automotive designer, 127 Goodwin Avenue, *Newark, N. J.*

RICHMOND, JOHN P. (A) comptroller, Bendix Corporation, 401 North Bendix Drive, *South Bend, Ind.*

SCHNEIDER, W. C. (A) draftsman designing automobile parts, Reo Motor Car Co., *Lansing, Mich.*; (mail) 424 North Capitol Avenue.

SKINNER, JAMES H. (J) sales engineer, Skinner Automotive Device Co., Inc., 1637 West Lafayette Boulevard, *Detroit*.

SOMERVILLE, NOEL FRANCIS (A) sales engineer, Motive Parts Corporation, *New York City*; (mail) 1379 Boulevard East, *West New York, N. J.*

TOWNSEND, LIEUT. GUY DUKER (S M) assistant superintendent of the aeronautical engine laboratory, Naval Aircraft Factory, *League Island Navy Yard, Philadelphia*.

WALKER, EDWIN M. (A) president, Schenectady Railway Co., 512 State Street, *Schenectady, N. Y.*

ZIMMERMAN, H. L. (A) chief engineer, De Luxe Products Corporation, Inc., *La Porte, Ind.*



## APPLICANTS FOR MEMBERSHIP

525

# Applicants for Membership

The applications for membership received between March 15 and April 15, 1926, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

BAKKEN, H. E., superintendent, American Magnesium Corporation, *Niagara Falls, N. Y.*

BALL, MANDELL H., tool maker, Bendix Brake Co., *South Bend, Ind.*

BARGE, WILLIAM FRED, tool designer, Lycoming Mfg. Co., *Williamsport, Pa.*

BARGER, LLOYD R., designer, Lycoming Mfg. Co., *Williamsport, Pa.*

BAUBIE, REX O., draftsman, Hupp Motor Car Corporation, *Detroit.*

BEHN, CARL, JR., sales engineer, Robert Bosch Magneto Co., *Chicago.*

BEHN, HAROLD E., tool engineer, Locomobile Co. of America, *Bridgeport, Conn.*

BISHOP, JOHN A., supervisor of motor vehicles, Socony Burner Corporation, *New York City.*

BLACK, STACY R., staff assistant to works manager, White Motor Co., *Cleveland.*

BOLTE, F. B., salesman, East Side Nash, *East St. Louis, Ill.*

BROOME, CLIFFORD E., engineer, William Ganshow Co., *Chicago.*

CERF, F. D., president, Stutz Chicago Factory Branch, Inc., *Chicago.*

CHAMBERS, KARL DUMAS, research, the Portals, *Asheville, N. C.*

CHARLES, WILLIAM O., service manager, Olds Motor Works, *Denver.*

COREY, C. H., New England manager, C. G. Spring & Bumper Co., *Cambridge, Mass.*

COREY, R. L., district manager, National Gauge & Equipment Co., *Chicago.*

CRAWFORD, HOWARD H., president and general manager, Crawford-Lewis Corporation, *Detroit.*

CROSSLEY, FRED R., assistant service manager, Earle C. Anthony, Inc., *Los Angeles.*

CULTICE, LEON W., draftsman, Buda Co., *Harvey, Ill.*

CURRIER, HOWARD S., assistant supervisor of design, White Motor Co., *Cleveland.*

DAILY, G. M., educational and research representative, Manley Mfg. Co., *York, Pa.*

DUFFY, JAMES T., JR., general superintendent, Steel Products Co., *Detroit.*

DUNK, WILLIAM, factory manager, H. H. Franklin Mfg. Co., *Syracuse, N. Y.*

EBEL, WILLIAM JOSEPH, instructor, Pratt Institute, *Brooklyn, N. Y.*

EHRlich, JACOB, research engineer, General Motors Corporation, *Detroit.*

ELLIOTT, CLARENCE VINCENT, instructor in drawing, mechanism and hydraulic laboratory, California Institute of Technology, *Pasadena, Cal.*

EVANS, O. G., sales engineer, Bearing Service Co., Proprietary, Ltd., *Melbourne, Australia.*

FATTLER, A. H., superintendent of manufacture, Benz Automobile Co., *Mannheim, Germany.*

FINKELDEY, WILLIAM H., assistant to chief of research division, New Jersey Zinc Co., *Palmerton, Pa.*

FLEETWOOD, C. A., sales manager, Fort Dodge Machine & Supply Co., *Fort Dodge, Iowa.*

GARNEAU, CHARLES E., sales manager, Irvington Varnish & Insulator Co., *Irvington, N. J.*

GAY, ERROL J., engineering department, Hupp Motor Car Corporation, *Detroit.*

GEORGE, GEORGE, automobile editor, Daily Telegraph Newspaper Co., Ltd., *Sydney, Australia.*

GILBERT, CARLTON GEORGE, Detroit representative for Federal Products Corporation, Providence, R. I.; Reed Small Tool Works, Worcester, Mass.; Stark Tool Co., Waltham, Mass.; and George Scherr, New York City.

GOULD, GARDNER S., sales engineer, Universal Grinding Machine Co., *Fitchburg, Mass.*

GRAHAM, MATTHEW P., chief engineer, Steel Products Co., *Detroit.*

GREINER, FRANK, Detroit representative, Landis Tool Co., *Waynesboro, Pa.*

HARRIS, A. H., superintendent, W. P. Herbert Co., *Los Angeles.*

HARRISON, HENRY P., master mechanic, H. H. Franklin Mfg. Co., *Syracuse, N. Y.*

HARTZELL, R. S., special representative, C. G. Spring & Bumper Co. of Illinois, *Chicago.*

HEBRON, ROBERT F., superintendent of garages, R. H. Macy & Co., Inc., *New York City.*

HEY, ROY ELKINGTON, junior draftsman, Pierce-Arrow Motor Car Co., *Buffalo.*

HOFFMAN, PAUL G., vice-president, Studebaker Corporation of America, *South Bend, Ind.*

HUMBER, CARROLL C., transportation superintendent, Longview Public Service Co., *Longview, Wash.*

IRWIN, B. F., designing engineer, Engineering Laboratories, *Des Moines, Iowa.*

JEACOCK, THOMAS W. H., president, Buffalo Bronze Die Cast Corporation, *Buffalo.*

KELLEY, JOHN A., superintendent of equipment, Barker Bros., Inc., *Los Angeles.*

LEE, FRED A., experimental shop foreman, International Harvester Co., *Springfield, Ohio.*

- LEECH, FIRST-LIEUT. PAUL H., Quartermaster Corps, Camp Normoyle, *San Antonio, Tex.*
- LEININGER, WILLIAM HENRY, research engineer, Pierce Petroleum Corporation, *St. Louis.*
- LOUTH, M. E., secretary and sales manager, Udylyte Process Co., *Kokomo, Ind.*
- LYZENGA, LOUIS A., designer, Acme Motor Truck Co., *Cadillac, Mich.*
- MCLEES, ROBERT, standards engineer, General Motors Corporation, *Detroit.*
- MACDONALD, CLAUDE F., production engineer, Huff-Daland Airplanes, Inc., *Bristol, Pa.*
- MARTIN, CHARLES F., automobile loss adjuster, Martin Adjusting Co., *Chicago.*
- MASSEY, KENNETH C., statistical clerk, Public Service Transportation Co., *Newark, N. J.*
- MEAD, HOWARD C., chief draftsman, Guide Motor Lamp Mfg. Co., *Cleveland.*
- MILLER, KAY C., production engineer, Sheldon Axle & Spring Co., *Wilkes-Barre, Pa.*
- MOREN, HUGO KARL, draftsman, Hupp Motor Car Corporation, *Detroit.*
- PELIZZONI, JOSEPH A., general superintendent, International Motor Co., *Allentown, Pa.*
- PFISTER, CHARLES F., *Baldwin, N. Y.*
- SIEGEL, JOSEPH, general manager, Metropolitan Distributors, Inc., *New York City.*
- STRATTON, L. H., service manager, Mosbacher Motor Co., *Wichita, Kan.*
- TEMPLE, HERBERT R., shop superintendent, H. J. Ruddle Co., *Los Angeles.*
- TIMPSON, T. W., assistant general manager, R. H. Macy & Co., Inc., *New York City.*
- TORON, ERNST W., chief engineer, Dr. L. Michaelis, Ingenieurburo, *Berlin W. 62, Germany.*
- TOWER, HARRY BRITTON, petroleum analyst, Standard Oil Co. of New York, *New York City.*
- TOWLE, H. LEDYARD, director of Duco color advisory service, E. I. du Pont de Nemours & Co., *New York City.*
- UNITED STATES ASBESTOS CO., *Manheim, Pa.*
- VON LEPEL, EGBERT, chief engineer, Lepel Ignition Corporation, *New York City.*
- WHITE, CHRISTOPHER, technical engineer, George B. Wuestefeld Co., *New Haven, Conn.*
- WILD, JULIUS E., vice-president, Robert Bosch Magneto Co., Inc., *New York City.*
- VEAGER, HARRY P., assistant superintendent, Fedders Mfg. Co., Inc., *Buffalo.*

